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The Sign

OF SMOOTH, SURE STOPS!

THE INDUSTRY'S FINEST POWER BRAKING SYSTEMS

More than two and a half million installations have made Hydrovac the undisputed leader in the field of power braking. And now Bendix Products offers Air-Pak, an air-hydraulic unit similar in design and principle to the Hydrovac. Air-Pak changes air pressure into hydraulic pressure by means of two direct connected pistons, thus combining all the well proven advantages of hydraulic brake action with an air brake system.

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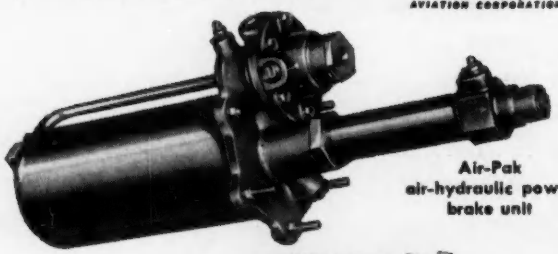
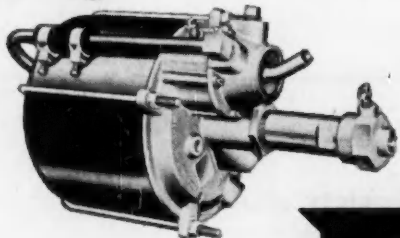


Air-Pak air-hydraulic power brake unit



Hydrovac vacuum-hydraulic power brake unit

BRAKING HEADQUARTERS for the AUTOMOTIVE INDUSTRY

Bendix Products Division

Largest Summer Meeting Bids French Lick Adieu

SAE bid au revoir to French Lick with the most colorful of all its Summer Meetings held June 3 to 8. More members than ever before enjoyed the traditional social events—and thrilled to a major innovation, the SAE Country Carnival on Wednesday evening. Arranged and operated by a "Corn Tassel Committee" headed by Cleveland's R. F. Steeneck and Mrs. Steeneck, this event set a new high in enjoyment for everybody at the meeting. Supporting Corn Tasslers were Indiana's Mr. and Mrs. W. K. Creson and Cleveland's Mr. and Mrs. K. R. Weise.

A dozen formal papers, a baker's dozen of round table discussions and 21 technical committee meetings furnished the vital engineering fare. Transmissions and powerplants got top billing in many of these presentations and exchanges, with lubrication and fuel problems getting major attention as well.

Two security-restricted sessions symbolized the meeting's military overtones. Army Ordnance brought a fleet of its tactical vehicles for inspection by the engineers. The exhibits ranged all the way from a jeep to the 15-ton monster T58 cargo truck.

SAE Council decision to take the 1952 Summer Meeting to Atlantic City was a news highlight of the meeting's closing days. Determination to provide Summer Meeting accommodations for every SAE member wishing to attend was the chief basis for the Meetings Committee's recommendation and Council's adoption of Atlantic City for the 1952 site. As opposed to the more than 100 members turned away from French Lick this year, AC's adjacent Ambassador and Ritz-Carlton hotels will even permit again opening the 1952 gathering to guests as well as members.

"French Lick Springs Hotel can furnish more rooms than any other resort hotel of its kind in the United States or Canada," Meetings Committee Chairman E. H. Kelley explained, "and for two years running it hasn't furnished nearly enough accommodations. There will be plenty of room at Atlantic City to meet our requirements."

Both formal and social aspects of SAE's au revoir meeting at French Lick were widespread and successful. Their story is told in the words and pictures which appear on following pages.

Technical sessions reemphasized the fact that while the automotive industry is highly competitive, it is also highly cooperative in many areas where engineering cooperation is in the best interest of the public.

Trade secrets were as closely guarded as ever, but the traditional SAE attitude toward exchanging other technical information prevailed. As one speaker explained that attitude, once a product is on the market, anyone can buy it and take it apart to see how it works . . . the competitive advantage

Continued on Page 66

Turbojets May Use

THE IDEAL starter for turbojets is yet to be developed. When it comes, it is likely to be a 1000 hp unit. Chances are that instead of being an electrical system, it will be a turbine system.

This view of starter development results from consideration of—besides power—these three basic factors:

1. Weight.
2. Suitability for operation under extreme cold temperatures.
3. Suitability as a completely airborne system.

Other factors which must be considered are:

- Bulk.
- Number of starts which may be made without refueling.
- If a special fuel is needed, the cost, fabrication, storage, handling, and supply problems introduced by the fuel.
- Vulnerability to enemy attack.
- Adaptability to many types of aircraft.

Present trends indicate that starters rated at more than 1000 hp will be used on turbojet engines in the near future. Our largest reciprocating engine, the 3500-hp R4360 engine, requires only a 5 hp starter. The reason for this disparity of starting power requirements is: A reciprocating engine requires starting assistance to only 2 or 3% of its rated speed, whereupon ignition may be initiated and the engine will develop sufficient power for satisfactory acceleration; on the other hand, turbine engines require assistance of a starter to 20% or more of rated speed. Since power is a function of speed and torque, high speed cranking is the reason for the high starter power required by gas turbines.

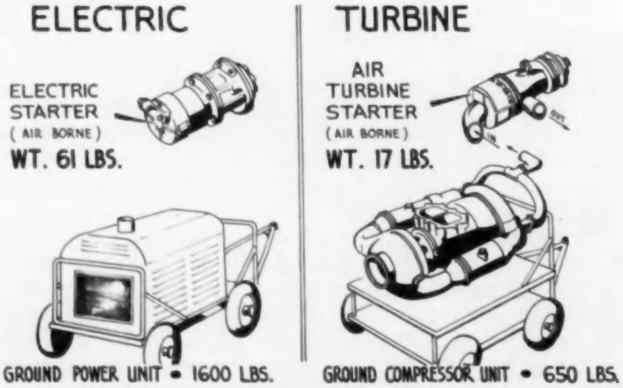


Fig. 1—Ground-powered electrical and air-turbine starter systems

The reciprocating engine went through the torments of being supercharged not long after it became airworthy. If a similar fate overtakes a turbojet engine which is rated at say 5000 lb thrust, an increase in pressure ratio from 4.5:1 to 7.45:1 will be accompanied by an increase in thrust to approximately 9200 lb and a decrease in fuel consumption from 1.15 lb per hr per lb of thrust to less than 0.9 lb per hr per lb of thrust. The redesign will be accompanied by an increase of compressor temperature rise from 325 to 480 F at design speed and 60 F inlet air temperature. This increase in temperature rise will necessitate building a greater portion of the compressor of steel rather than aluminum. This together with the increase of compressor and turbine stages will increase the moment of inertia of the engine rotor.

The increase in engine thrust was brought about by an increase in pressure ratio and an increase in airflow through the engine. At design speed, the airflow is increased by approximately two thirds. Increased airflow and pressure rise will increase the engine rotor drag during starting.

Another effect of the redesign is a more rapid deterioration of compressor efficiency as speed is decreased. An evidence of this effect is an increase in engine idling speed. Whereas the engine which delivered 5000 lb of thrust idled at about 27% of rated speed, engine manufacturers have estimated that an engine such as the 9200 lb thrust engine may have an idling speed as high as 50% of rated engine speed. Hence we must expect a considerable increase in the starter disengagement speed.

The increase in engine rotor moment of inertia, the increase of engine drag, and the increase of starter disengagement speed will increase the power required to start the high pressure ratio engine. Estimates show that the 5000 lb thrust engine will require approximately 60 hp for a 20 sec start and approximately 400 hp for a 3 sec start; the 9200 lb thrust engine will require approximately 180 hp for a 20 sec start and 1200 hp for a 3 sec start. More than a six-fold increase of starter power is required to reduce the starting cycle from 20 to 3 sec. Of course high strength drives will be required for

Turbine-Type Starters

EXCERPTS FROM PAPER BY

William D. Downs, Power Plant Laboratory, Air Materiel Command, Wright-Patterson Air Force Base

• Paper "Starters for Turbojet Engines" was presented at the SAE Annual Meeting, Detroit, Jan. 8, 1951. Opinions expressed in this paper are the author's and do not necessarily coincide with official opinion.

engines which are to be started in a 3 sec period.

On typical turbojets, breakaway drag has been smaller than the peak running drag. At low speed, the engine drag is low. Engine drag increases as speed increases in a fashion characteristic of a blower. At −65 F, the increased density of charge will increase the drag by about 35%. A much greater increase may be caused by mechanical friction. In one axial flow turbine tested at the Power Plant Laboratory, Air Materiel Command, low speed drag at −65 F was double the normal drag.

Tactical considerations will require that we equip interceptors and some other types of military aircraft with self-contained starter systems. In a service report on the starting of aircraft equipped with ground power electrical starters, the maintenance officer of one of our interceptor bases commented on ground supported systems: "Even if the proper amount of powerplant operating personnel, vehicles, and drivers were available the cost of equipment and the expenditure of man-hours for starting a large number of aircraft in a short time are beyond a doubt excessive."

Turbojet aircraft presently in service are started using either electrical starters or starter generators. Primarily because of weight consideration, development endeavor has passed to other types. Turbine starters driven by compressed air or by the products of combustion of a monopropellant look promising. In the case of the air turbine, the air comes from a gas turbine compressor unit. The compressor may be airborne or ground equipment. Turbines driven by the decomposition products of hydrogen peroxide have also been investigated.

The starter generator is very advantageous from the point of view that the starter will serve as a generator while the aircraft is in flight. Therefore, most of the weight of the motor may be charged to the generator duty. However, reliability of a generator which is subjected to the strains of starting remains doubtful.

Fig. 1 shows the starter elements of an electrical system and an air starter system. The 61 lb electrical starter is rated at 16 hp. The 17 lb air starter is rated at 35 hp. The air starter will provide a faster acceleration for the turbojet engine with a weight saving of 44 lb per engine. In addition, large weight savings in ground equipment can be anticipated. The generating set for the 16 hp electrical

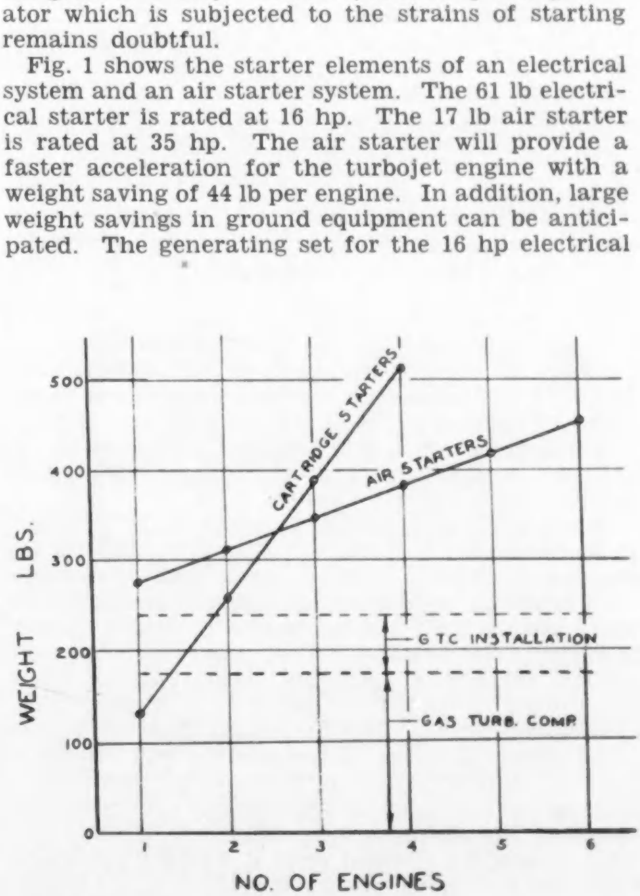


Fig. 2—Comparison of weight of self-contained air starter system and cartridge starter in single-engine and multi-engine aircraft

starter weighs 1300 lb. The gas turbine which provides the air for the 35 hp air starter weighs only 88 lb. Assembled on a trailer with fuel cells and accessories, it is expected to provide a transportable ground power source which will weigh not more than 650 lb.

The systems illustrated are referred to as ground-supported starter systems, since the prime mover remains on the ground. An aircraft is said to have a self-contained starter system if the fuel and the device for converting the chemical energy of the fuel are contained in the aircraft.

The air starter is readily adaptable as a self-contained starter system. It is light weight, and it will use the fuel of the aircraft. The 16 hp electrical system may be made to approach being self-contained by using a 150 lb battery. One such battery will provide sufficient energy to crank the 16 hp starter for a total of approximately 180 sec, but this performance cannot be obtained when the battery is not fully charged. Nor can it be obtained when operating at very low temperatures.

Cartridge starters can be made small and light. But they have compensating problems. The cartridge starter's high flame temperature leads to the requirement that the starter operate with a burning cycle of very short duration. Maximum success has been obtained by the use of a 3-sec burning cycle. Propellants having a lower flame temperature are not used because such propellants presently available have the following disadvantages:

1. Less energy per unit weight of charge.
2. Ignition difficulties.
3. More residue and more solid matter in the combustion gases.

For the present, a 3-sec start is required by the cartridge starter. The short starting cycle will result in high power starting requirements and a weight penalty in the starter and possibly in the engine.

The solid propellants presently available are temperature sensitive. That is, the burning rate varies with the temperature of the propellant. The variation is approximately -0.2% per deg F. Hence starter power falls at low temperatures, whereas the power required by the turbojet increases.

There is also a storage problem. Propellants presently available tend to crack when stored below -40 F. Cracking increases the burning area, and the burning area increase is likely to become so great that an explosion may occur if the propellant is ignited.

The propellant is an extra supply item; however, it is similar to the propellants used in solid rocket ammunition and in solid jet assist take-off devices.

In addition to the flame temperature problem, there are design problems in the cartridge starter involving safety devices. These concern protection against explosions, protection against firing when the breech is not fully secured, and protection against overspeed. The overspeed protection is a most serious problem. Overspeeding will result in the event of a drive failure. The overspeed condition must be counteracted by wasting the energy of the cartridge, inasmuch as the combustion of the cartridge cannot be stopped once it has been started. Moreover starter torque for a single-stage turbine will remain near its maximum value at the limiting speed of the starter. This is so because the high temperature and high pressure of the cartridge gases produce, within the turbine nozzles, a jet of gases which has a velocity much greater than the limiting pitch-line velocity of the turbine.

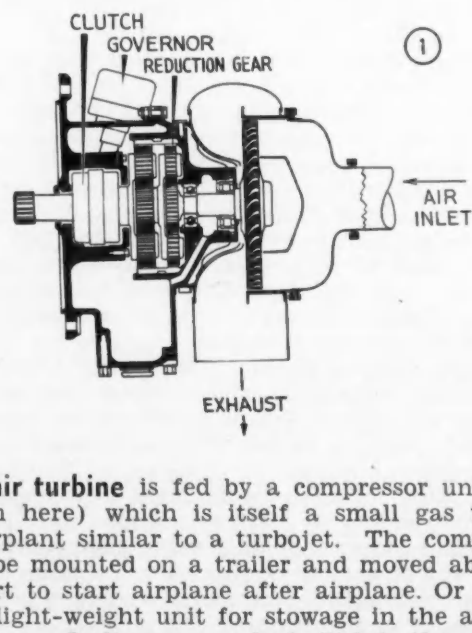
As a result of the high torque at the limiting speed of the starter, the starter has a very great tendency to overspeed. In some designs of cartridge starter employing a single-stage turbine, the limitation of the speed has been accomplished by diverting the jet of cartridge gases away from the turbine wheel or by removing the turbine wheel from the jet of cartridge gases. Because of the great tendency to overspeed, a negligible time delay is required of any device chosen to sense the overspeed and counteract the overspeed condition. A more desirable approach to the design of overspeed protection in the starter may be the use of a multistage turbine designed so that its torque falls to a small value at the maximum allowable operating speed of the starter turbine.

Other problems introduced by the cartridge starter involve the duct which must pass through the engine inlet from the cartridge housing to the starter. This duct will carry gases at 1000 psi and and approximately 3000 F.

Engine problems introduced by the cartridge starter involve the fuel system, ignition system, and combustion chamber of the engine. These must be such that the engine can light off satisfactorily

TURBINE-TYPE

IN turbine-type starters, a high-speed turbine extracts energy from a working fluid such as (1) compressed air, (2) combustion products of a monopropellant, or (3) steam



The air turbine is fed by a compressor unit (not shown here) which is itself a small gas turbine powerplant similar to a turbojet. The compressor may be mounted on a trailer and moved about an airport to start airplane after airplane. Or it may be a light-weight unit for stowage in the airplane after use. Or it may even be built into the airplane and used also to pressurize the cabin and power electrical equipment.

within the 3-sec period and at the high speed to which the starter will accelerate the engine. Otherwise the energy spent by the starter will be wasted when the engine slows down to a speed at which it can satisfactorily start.

Fig. 2 shows a comparison of the weight of the air starter and of the cartridge starter in single engine and multi-engine aircraft. Tubing connecting the nacelles of a multi-engine aircraft is not charged against the air starter inasmuch as that tubing will normally be used for air for cabin charging, air for deicing, and air for pneumatic accessory drives. For the air starter system only, one 175 lb gas turbine compressor is required regardless of the number of engines. Also, 65 lb was added to the air starter system to account for the installation equipment required by the gas turbine compressor. The cartridge was estimated to weigh 10 lb. The housing for the cartridge weighs 25 lb. The cartridge housing is empty, but two cartridges are stowed in the aircraft. The single-engine installation of the cartridge starter weighs 128 lb. A six-engine installation of the air starter weighs 453 lb.

From the point of view of weight and volume, the cartridge starter will be preferred over the completely self-contained air starter for single-engine and twin-engine aircraft. However, if the gas turbine compressor unit is installed in a detachable blister or pod, the compressor unit may then be carried, making the aircraft self-sufficient while moving from one airfield to another. Or, on the other hand, the compressor unit and its blister could be detached for combat missions. Then only the 28 lb starter and the weight of some tubing could be charged to an air starter. So that the air starter system may find use in some single-engine and twin-engine jet-propelled aircraft.

Likewise, the cartridge starter may find application on multi-engine aircraft in an installation such that one or two engines are started by the cartridge starter and the remaining engines equipped with air starters which would be energized by air bled from the first engine started.

The development of the hydrogen peroxide starter is not being pursued because:

1. Hydrogen peroxide is a special fuel item presenting problems in procurement, storage, and handling.

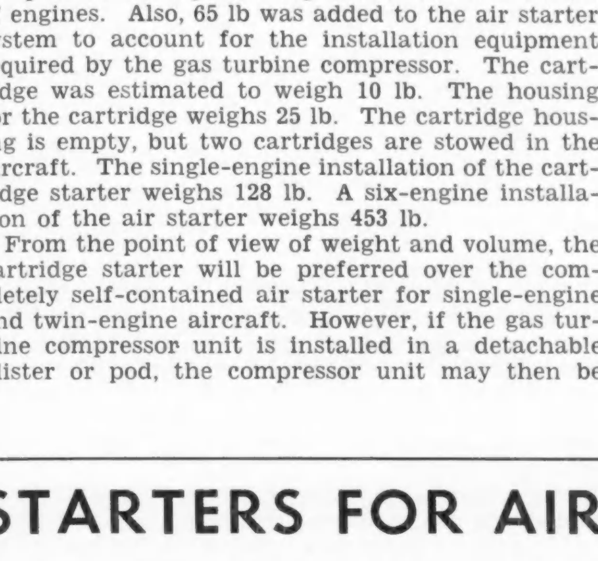
2. Hydrogen peroxide of 90% concentration, which would be used in this starter, has a freezing point of +13 F.

Military considerations and design considerations are expected to determine the type of starter system which will be used.

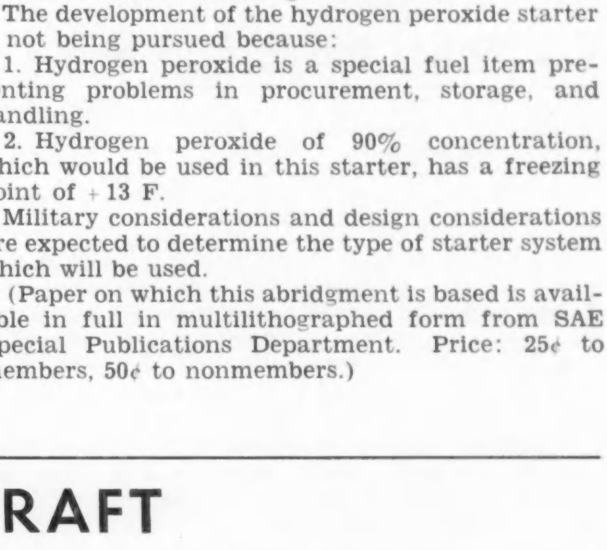
(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

STARTERS FOR AIRCRAFT

plus oxygen decomposed from hydrogen peroxide. The energy is transmitted along the turbine shaft, through the reduction gearing, to the turbojet rotor. The gearing reduces speed to a value suitable for cranking the engine. The governor shuts off flow to the turbine when cranking speed reaches the maximum.



The cartridge starter powers its turbine with the combustion products of a solid monopropellant. A typical propellant contains 59% nitrocellulose, 20% nitroglycerine, and various additives to control burning rate and bind the other ingredients. Black powder set off electrically ignites the propellant. Combustion chamber pressure reaches 1000–1500 psi. Temperature of the combustion products is around 3000 F.



The hydrogen peroxide starter turbine has a combination of steam and oxygen for its working fluid. Hydrogen peroxide of 90% concentration is the source. The pump feeds the hydrogen peroxide to a catalyst chamber operating at 300 psi. The catalyst decomposes the hydrogen peroxide into steam and oxygen at approximately 1350 F. These decomposition products are a very desirable working fluid for the turbine.

LPG Is Plentiful

BASED ON PAPERS BY

F. E. Selim and R. C. Alden, Phillips Petroleum Co.

• Paper "LP-Gas as Motor Fuel" by F. E. Selim was presented at SAE Mid-Continent Section, Dec. 8, 1950. Paper "LP-Gas for Motor Fuel" by R. C. Alden and Mr. Selim was presented at SAE Annual Meeting, Detroit, Jan. 8, 1951.

THIS country is confronted with huge potential production of liquefied petroleum gas—a nearly ideal motor fuel—at manufacturing costs several cents per gallon under gasoline.

In a national emergency, LPG could go a long way in cushioning the essential civilian economy against the impact of military requirements for aviation and motor gasolines. In war or peace, use of LPG as a direct motor fuel is a substantial petroleum conservation measure.

LPG is derived from (1) the natural gas produced along with oil from the wells and (2) the refining of crude oil. LPG from natural gas is mostly propane and butane; LPG from refinery gases often contains appreciable amounts of propylene and butylene as well. All four behave similarly as motor fuels.

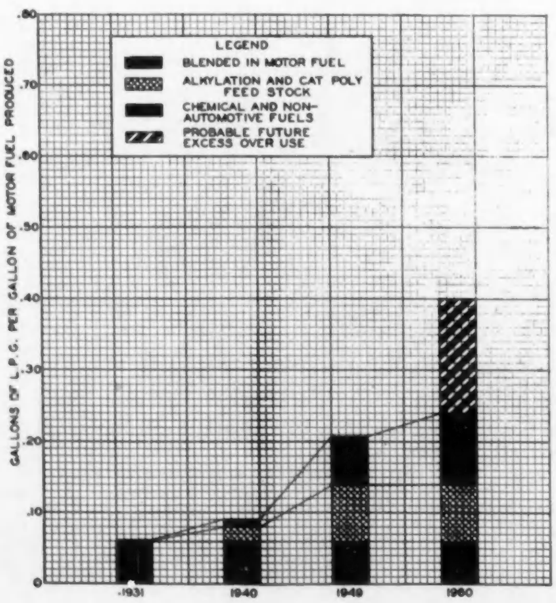


Fig. 1—Production of LPG, including liquefied refinery gas, for consumption in established uses, relative to motor fuel production

Fig. 1 shows how much LPG we have used and what we will have available to use in the next ten years as compared to gasoline. This is a plot of the production of LPG since 1931 in terms of per cent of motor fuel production. Over the years, about 6% of the LPG used has been butane blended in motor fuel to achieve the volatility needed for easy starting.

Motor fuel consumption has risen sharply in this period. So the amount of butane consumed for this purpose has shown a corresponding marked increase. In 1931 the other uses of LPG were so small as to be insignificant as compared to gasoline produced.

In 1940, we were still using about 6 gal of butane for every 100 gallons of gasoline produced. But we were then using an amount of LPG in refineries, for conversion to motor fuel, about equal to 2 gal for every 100 gal of motor fuel produced and were selling as LPG about 1 gal for every 100 gal of motor fuel produced. In 1949, we were still using about 6 gal of butane for blending in every 100 gal of motor fuel produced, but the amount used for conversion to motor fuel by various refining processes had increased to about 8 gal for every 100 gal of motor fuel. We were selling as LPG about 7 gal for every 100 gal of motor fuel produced.

By 1960, we believe that the petroleum industry will be producing about 40 gal of LPG for every 100 gal of motor fuel. About 6 of these gallons will be used directly in motor fuel blending, about 8 will be processed into motor fuel, 10 will be sold for present uses as LPG, and about 16 gal will be left over for new uses such as direct consumption in engines.

Fig. 2 shows the total LPG and LRG content of natural gas produced and of crude oil processed at refineries. (LPG from refineries is sometimes called liquefied refinery gas or LRG.)

This chart shows a total of about 35 gal of LPG was available in 1931 for every 100 gal of motor fuel produced. This figure had jumped to about 44½ gal in 1940, to 52 gal in 1949, and is estimated to reach about 61 gal by 1960. The chart also shows the proportions of this potential supply which were

and Cheap

In this second article of SAE Journal's series on liquefied petroleum gas, the authors say that the excess of LPG produced over that used is increasing at a rate that behooves us to investigate LPG as a direct motor fuel—especially in view of possible wartime demands for gasoline. The supply of LPG, they indicate, is great enough to fuel all farm tractors, all trucks, and all buses, in addition to a normal increase in requirements for present uses of LPG.

The first article in this series, a digest of the recent SAE paper by Leonard Raymond, surveyed the use of LPG as a fuel for automotive vehicles. The series will continue with digests of the papers by A. J. St. George, and M. J. Samuelson.

available from refineries as a byproduct of crude oil processing and how much of it was available from the processing of natural gas.

Fig. 3 shows the total LPG in natural gas reserves and in crude oil reserves—again in terms of the per cent of motor fuel in reserves. This chart shows that in 1931 there were approximately 48 gal of liquefied petroleum gas for every 100 gal of material in the crude oil reserves which could be made into motor fuel. By 1940, this had jumped to 61 gal of LPG for every 100 gal of motor fuel. By 1949, it was about 81½ gal for every 100 gal of motor fuel. The prediction is that by 1960 it will reach approximately 91 gal of LPG in reserve for every 100 gal of material which can be economically processed into motor fuel.

A tremendous increase in natural gas used during the past few years has been brought about by the construction of new natural gas pipe lines. When you remember that there is approximately 2 gal of LPG in every thousand cubic feet of natural gas produced in the United States, you can see that the potential supplies of LPG available from this source alone are staggering.

In addition to the natural gas produced for sale as gas, there are huge quantities of gas processed in what we call cycling plants. These plants take the natural gas produced in the field containing butane, propane, and natural gasolines, remove at least a portion of the liquid materials, and return the natural gas and the unrecovered liquid back to the ground.

On the basis of total gas processed for sale and gas processed at cycling plants, Fig. 4 shows the potential production of LPG from these two sources alone as compared to the sales of LPG by the LPG industry. In 1948 the industry sold about 2.75 billion gal of LPG against a potential production of some 15 billion gallons of LPG. Added to the amount sold as LPG is the amount used in the refineries for blending of motor fuel and in refining processes for conversion to motor fuel, which probably accounts for an amount about equal to the LPG sold. In other words, the total use of LPG in 1948 was approximately 5½ or 6 billion gallons against a total potential production of 15 billion gallons. This leaves a surplus of some 9 billion gallons which was available but was never recovered.

It is possible to leave an appreciable amount of propane in natural gas transmitted through the pipelines. However, this amount is limited by the fact that the pipelines usually operate under very high pressures. Only a certain amount of propane can be left in piped natural gas before the propane begins to separate out as a liquid. Liquids cannot

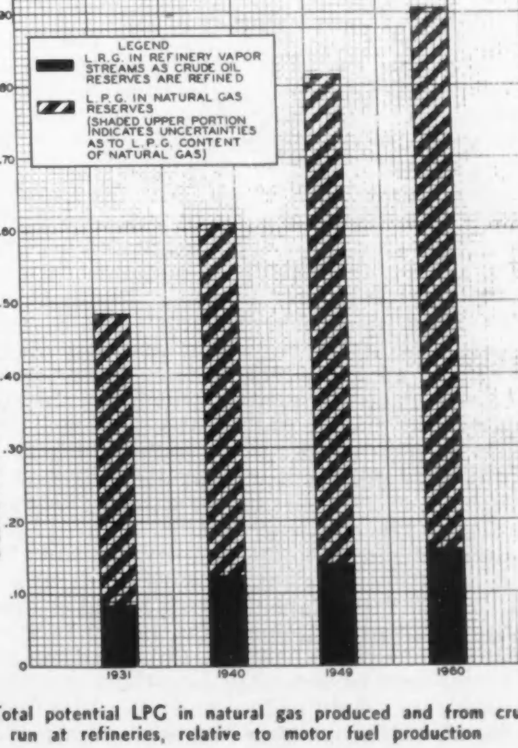


Fig. 2—Total potential LPG in natural gas produced and from crude oil run at refineries, relative to motor fuel production

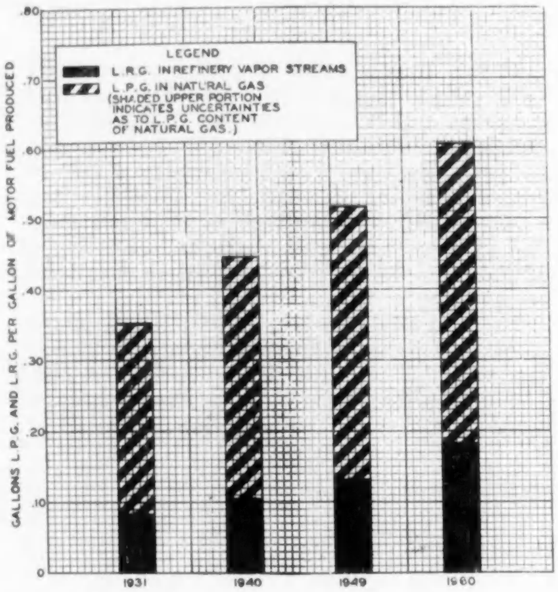


Fig. 3—Total potential LPG in natural gas reserves and crude oil reserves relative to motor fuel in reserves

be handled in the gas pipelines. Furthermore, the value of propane sold as natural gas in the pipelines is very low.

The propane remaining is usually disposed of by burning in a flare or in many cases by burning in the refinery as fuel. In some cases it is pumped back in the ground to be recovered later. Obviously, the disposing of these materials by flaring is undesirable. However, when the liquid must be removed before natural gas can be put into the pipelines and there is no home for the liquids removed thereby, the natural gas producer has very little alternative and is forced to dispose of the liquids as best he can. The Texas Railroad Commission has studied this waste of natural resources and has passed some very stringent anti-flaring laws. These are forcing more and more of the gas producers either to use the liquids so produced or to return them to the ground for later use.

Some people have argued that the use of LPG as motor fuel cannot become practical except in very restricted areas in the United States because these fuels are not available in all sections of the country.

The answer to that argument lies in the parallel with other petroleum products. Fig. 5 shows that natural gas reserves, which are one of the two sources of LPG, are located in the same geographic areas as crude oil reserves, which are the source of other motor fuels. There was a time when gasoline could be purchased only in gallon cans at grocery stores—and not every grocery store carried it. But it was not many years before gasoline was available at almost every intersection.

Gasoline moves to its numerous outlets by pipeline, tank cars, barges, tankers, and tank trucks. All of these means are now being used to move propane. Phillips Petroleum Co. now has a pipeline from West Texas to LaJunta, Col. handling propane. This line will be extended into Denver by the first of next year. Phillips also has a pipeline from West Texas to Chicago, which has been pumping butane for many years. Propane can move in this line as soon as the necessary storage facilities are installed at the terminals. Undoubtedly there are many other pipelines in the country and will carry propane as soon as sufficient demand exists to justify the installation of the necessary facilities.

In other words, the petroleum industry has demonstrated that it has sufficient flexibility and adaptability to put its products wherever the customer needs them. There is no reason why this cannot be true for propane as well as for the other more common fuels.

One survey indicates that there are about 4200 wholesale propane bulk storage plants in the country. This seems a substantial framework on which to build a nationwide distribution system for furnishing LPG to trucks and buses.

The oversupply of LPG is reflected in the decline in the F.O.B. price of propane relative to gasoline. Fig. 6 shows the price differentials of propane, natural gasoline, and fuel oil, under gasoline. The price curve for propane refutes the contention that prices, particularly yearly average prices, fluctuate violently.

The price advantage for natural gasoline is perhaps of greatest long-term significance because the technology and economics of the liquefaction of LPG from gases is quite analogous to the liquefaction of natural gasoline from natural gas.

A typical natural gas contains about 1.5 gal of propane, 0.9 gal of butanes, and 0.9 gal of pentanes-and-heavier per thousand cubic feet. The pentanes-and-heavier is almost 50% pentanes with rapidly decreasing proportions of hexanes, heptanes, octanes, and so on. Natural gasoline is the pentanes-and-heavier with a little of the butanes included. Natural gasoline is too volatile for use as a conventional motor fuel and is blended with gasoline from crude oil. The production of natural gasoline

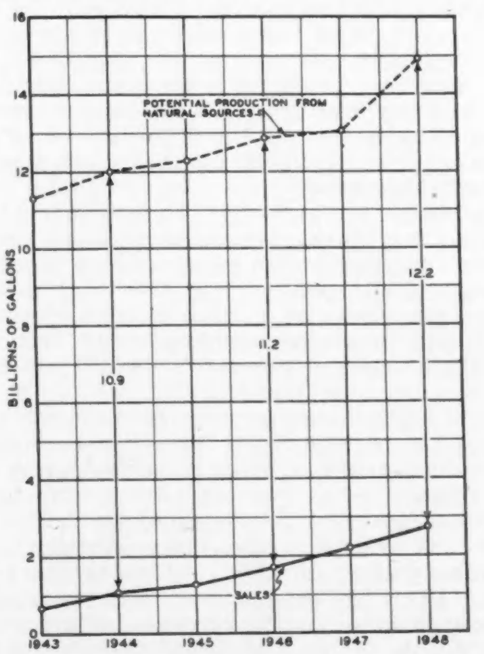


Fig. 4—Annual potential and annual sales of LPG

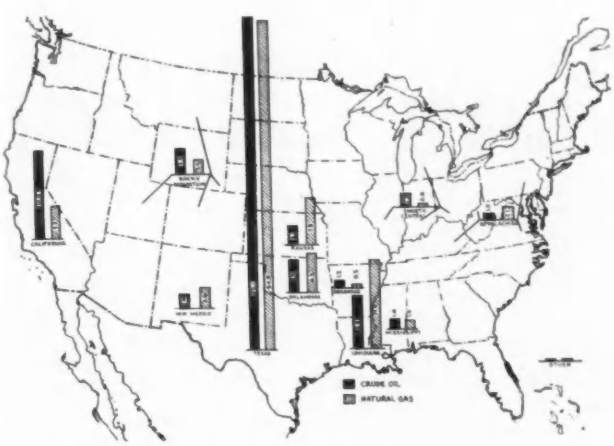


Fig. 5—Geographical location of LPG reserves, in per cent

has been about 10% of the production of motor fuel for 30 years or more. Except for the earliest period, the price relationship has approximated that shown in Fig. 6.

Much of the LPG produced from natural gas to date has been that liquefied as an incidental result of the liquefaction of natural gasoline, or by comparatively minor additions to natural-gasoline extraction plants. At such plants—under corresponding conditions of liquid content, pressure, volume, and temperature of the gas—it is more costly to liquefy propane and butane than to liquefy natural gasoline. However, offsetting this fundamental disadvantage are three significant facts:

1. The liquid content of propane and excess butane is usually twice as great as of natural gasoline.
2. The pressure at which natural gas is handled is rapidly increasing.
3. The volumes of natural gas being handled are rapidly increasing.

Although different raw material values apply, much the same considerations hold for the liquefaction of LPG from refinery vapors (LRG). The widespread use of catalytic cracking has made refinery vapors much richer in LPG.

From these considerations it seems reasonable to conclude for the long term that LPG can be economically manufactured and marketed at about the same price levels as has been the case with natural gasoline, or at several cents per gallon under gasoline.

The fact that LPG requires pressure tankage from manufacturing plants to utilization points introduces a potential added element of cost in comparison with gasoline and diesel fuel. The cost of tankage is a very small proportion of the investment necessary for the manufacture, transportation, and distribution of any fuel. Actually, in some respects this apparent handicap of added storage cost for LPG may be a blessing in disguise. It forces management and engineering attention on the tankage problem, often resulting in economies that could be used for the other fuels but which are quite unlikely to be so used primarily because of competition and because much of the investment for the others is already made.

Thus, it is a foregone conclusion that the distribution of LPG as a motor fuel cannot tolerate the profligate use of wholesale and retail outlets typical of gasoline merchandising. There is the distinct possibility that so great a rationalization will be achieved that distribution costs will actually be less for LPG than anyone would presently expect.

In many instances, the cost of railroad transportation is already less in cents per gallon for LPG than for gasoline or gas and fuel oils. The difference is small and varies with the section of the country.

An indication of the cost brought about by the need for pressure storage comes from past experience, which indicates that LPG storage costs to the consumer run between ½¢ to 1½¢ per gal throughput, depending upon the size storage installed and the volume of fuel used. These costs are based on short amortization periods. (There is, of course, a cost for storage facilities for other liquid fuels.)

An interesting development in regard to large-volume pressure storage is the utilization of man-made caverns in water-soluble salt strata. Proponents of this scheme estimate it reduces the investment in pressure storage by 90% or more. This development suggests that anyone interested in large volume LPG storage in a particular area should consult a geologist as to the likelihood of finding suitable salt strata in the vicinity.

The question of the effect of specific geographic areas on distribution costs is one for the transportation experts to diagnose. For the immediate future, it seems self-evident that the northeastern part of the United States is at a disadvantage relative to the rest of the country because of its distance from large sources of supply and the lack of bulk transportation facilities, considering the large market potential in relation to local production.

Just as it is going to require a lot of doing to develop suitable engine-equipment combinations for LPG it is also going to require a lot of doing to achieve adequate distribution for LP-Gas. It is, therefore, a foregone conclusion that the economics of distribution will dictate that LPG will be used first as a direct motor fuel either by large users or in cases where other markets for LPG have already justified the establishment of distribution and storage facilities. The use of LPG as a direct motor fuel in itinerant highway equipment is probably quite a distance in the future, except in special circumstances.

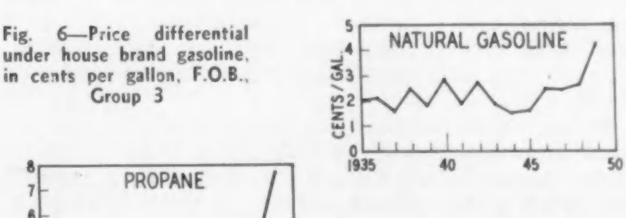


Fig. 6—Price differential under house brand gasoline, in cents per gallon, F.O.B., Group 3

I Was a Liaison Officer

in Korea for Detroit Arsenal on Patton Tanks – and covered 5300 miles in a Jeep and made 14 air flights in trying to keep up with them . . . .

EXCERPTS FROM PAPER BY

Major W. O. Miller, Ordnance Corps, Aberdeen Proving Ground

• Paper "The Patton Tank in Korea" was presented at SAE Detroit Section, May 7, 1951.

I WAS a liaison officer for Detroit Arsenal on Patton Tanks and covered 5300 miles in a Jeep and made fourteen individual air flights trying to keep up with them. My mission concerned tanks and not vehicles in general; therefore, most of my comments will concern the Patton Tank with incidental references being made to other types of vehicles as I saw them.

The acceleration and cross-country and hill-climbing ability of our automotive equipment, coupled with firepower, represents our main advantage. These factors have enabled us to overcome a foe who is vastly superior in numbers.

The countryside in Korea is exceptionally mountainous and many of the mountains are devoid of vegetation. As rice is the principal crop, it is grown on almost every acre of flat land available. As a matter of fact, the flat land is so valuable for agriculture that graveyards are located on the sides of hills.

Roads in Korea are very narrow, winding, hilly, and composed mainly of dirt and gravel. In most cases, hard-surfaced roads are found only within the larger cities. Tank operations were conducted over such roads, as well as over mountainous trails which often approach 60% slopes. Almost everywhere, vehicle operations are channelized and confined to these narrow roads since either soft rice paddies or mountains flank the roadsides.

With such poor roads and an exceptionally limited rail net, the problem of supply becomes a most difficult one.

The people of South Korea are patient, hard working, able to endure the ordeals of their bitter winter while existing on a very meager diet. They depend primarily on manual labor to accomplish the majority of their tasks. Having been farmers for many centuries, they are not mechanically minded. The standard of living is very low. (A general in the South Korean Army receives $22.00 a month.)

In the beginning, the civilian populace were eager to participate in the struggle. Now, the many retreats and advances have caused many to become apathetic. All that many now desire is something to eat and a place to sleep.

Enemy tactics seem to utilize the principle of mass to accomplish an objective. Large numbers of troops, night operations and encirclement are used time and time again. These tactical techniques, coupled with horses and ponies for maneuver and the blowing of bugles, have presented new problems for field commanders. The supply of ammunition to machine gun emplacements has been difficult.

Under these conditions, our tanks operated.

Operations were conducted during the heat of summer and during the winter months when temperatures reached as low as -10 F to -15 F. Snow and ice, often encountered, when combined with low temperatures and lack of proper winterization materials, made operations extremely difficult.

The Patton Tank was detached to operate with British, Australian, and South Korean troops and encountered both North Korean and Chinese troops.

Men of the 9th Infantry Regiment, 2nd Infantry Division seated on an M46 tank awaiting attempt of North Korean troops to cross the Naktong River

Forging through enemy resistance, these tanks fought during day and night. They were hit with 85mm shells and on down to small arms. And they ran over mines on numerous occasions. One tank was hit 16 times by large caliber AP and HE (mostly 85mm) but was not seriously damaged and returned to action the next day.

M46 Tanks operating in Korea represented the earliest production designs. Although they did contain many deficient components subsequently corrected in production to make a much more efficient and reliable tank, they were the "masters" in Korea.

From the break-through at Taegu to within 15 miles of the Manchurian Border, the M46 eliminated most enemy opposition and proved itself the most maneuverable tank yet designed.

During the five-month period of observation, the tanks covered approximately 125,000 road miles under all types of conditions. The average mileage was approximately 1000 miles with one tank having 1980 miles.

Commendable Performance

Automotive equipment in general performed very well, but—with the exception of the Patton Tank—most of it was the same as in World War II. It is difficult to compare the performance of our automotive equipment with that of the enemy. Their equipment is woefully inadequate from an automotive standpoint both as regards the equipment available to them and their manner of taking care of it. During my five months in Korea, the only vehicles I saw were 1-½ ton trucks which had been made or at least assembled in Russia. Special purpose vehicles, such as wreckers and large transport vehicles, were very seldom encountered. Winterization, waterproofing and 24-volt systems were not observed on their vehicles.

Our transport vehicles accomplished the missions assigned with good results. The principal difficulty was the large volume of broken springs and shock absorbers due to the poor roads. It would appear that stronger springs might well be used as road nets are limited and overloading of vehicles is difficult to avoid in combat operations.

It is easier to compare combat vehicles since considerable numbers of tanks and self-propelled guns were used a great deal by the enemy. It can be stated that the overall performance—maneuverability, speed, and ability to resist shell fire—of the Patton Tank was outstanding in comparison with the T34-85 mm Medium Tank of the Russians—pardon me, North Koreans. Many of the Patton individual items gained favor. A few of the more outstanding are:

1. *Engine:* The air-cooled engine has proven out very well and the elimination of need for anti-freeze considerably lessens the logistics load.

2. *Transmission:* The automatic (torque converter) transmission makes possible a degree of maneuverability never before realized in tank operations, makes it possible to train drivers at a much faster pace and measurably reduces driver fatigue.

3. *Rubber Tracks:* With the new type rubber being employed, the life of our rubber tracks has been just about tripled. This new process rubber brings us to the "time for decision" as to whether steel or rubber tracks should be used in combat areas. At the present time, both types of track are in use and this represents a supply as well as a production problem. With such long-lasting rubber tracks, steel tracks have very few advantages. Rubber can be used for training in this country without danger of marring the road surfaces and still provides

better service in combat areas. It is lighter and affords better friction characteristics for snow and ice operations and it now appears that there will be sufficient supply even in an emergency.

4. *Electrical:* Starting motors and generators held up very well and, therefore, caused very little maintenance trouble.

5. *Suspension:* Road wheels, arms, bearings, torsion bars, shock absorbers, and related items performed very well and practically no replacement or repair was necessary.

6. *Oil Lines:* During entire period of observation, not one oil leak occurred in the new type oil lines utilized. This is a major step forward as far as tank maintenance is concerned as oil line leaks were previously a major problem.

Tank Comparison

The enemy utilized the Russian T34/85mm Tank against us, and it was very effective until our medium tanks were able to get into battle. When our medium tanks engaged the T34/85, very good results were obtained even though the enemy tank had many desirable features. It is difficult to compare two pieces of equipment in all respects, but I would like to compare some of the salient features from an automotive standpoint. (Table 1.)

Future Requirements

We can break combat vehicle design problems into two groups—those common to the the tank from a design standpoint and those related to operations in general.

a. Design

(1) *Lighter Tanks:* The tank designer is always striving for lighter tanks, provided the gun caliber is not decreased and the armor protection is not materially reduced. Thus, only essential items should be included, over-design carefully guarded against and lighter alloys utilized.

(2) *Suspension:* Suspension is one of the most

Table 1

M46 (Patton) Tank Compared to Russian T34 Tank

Item	Patton M46	Russian T34	Comments
Weight (Tons)	48	35	Patton provides more armour protection.
Engine	V-type 12-Cyl. Gasoline	V-type 12-Cyl. Diesel	No comment.
Cruis. Range	70 +	150 +	This is one of outstanding features of T34 Tank which is gained by auxiliary fuel tanks. Travel farther on less fuel. Difference would not be as great if vehicle weights were same but would be noticeable.
Horsepower	810	500	M46 has more horsepower. Investigations are presently underway to reduce horsepower in future medium tanks as well as vehicle weight.
HP/Weight Ratio (HP/Ton)	16.9	14.3	The T34 delivers 85mm gun to battle with less HP/Ton than the M46 requires to deliver a 90mm gun but does not have speed, maneuverability and armor protection of M46.
Speed (mph)	Above 35	30–35	M46 is presently so fast that steps are being taken to gain more power in low range.
Transmission	Automatic	Manual	M46 transmission provides great maneuverability and driver ease.
Cooling	Air	Water	Air-cooled engine is a great advantage. No antifreeze, less cooling air required, and maintenance reduced.
Tracks	Double Pin, Rubber and Steel	Single Pin, Steel	The single pin is easy to change in the field and this is its major advantage.
Simplicity	Complex but Efficient	Reduced to Bare Essentials (In many instances has been reduced below acceptable standards.)	T34 Tank has only bare essentials and is easier to supply and maintain. M46, although having more accessory items, is more efficient but more difficult to maintain. For example, our instrument panel has over 20 operating instruemnts and switches while the T34 has only 6 or so.

vulnerable points on any tank in combat. Road wheels, tracks and support rollers, when damaged by enemy shell fire, can immobilize a tank. To properly protect the suspension with armor plate would require considerable weight, too much for the tank to carry about in combat. Thus the problem is difficult to solve and will no doubt require major design changes to effect correction. . . . Track throwing is an age old problem. In Korea a large number of tracks were thrown. Work in this field should be directed toward eliminating the possibility of tracks being thrown without accomplishing a major modification.

(3) *Gas Consumption:* Our civilian engine production utilizes the gasoline engine and this fact is naturally reflected in our military engines. The power output per given volume of engine makes the gasoline engine desirable for tanks—and existing adequate facilities for manufacture makes it desirable in transport vehicles. Serious consideration should be given to reducing fuel consumption for tactical, logistical and economy reasons. Our present tanks consume huge quantities of gasoline which is one of our greatest supply problems to date. This problem should be approached from the standpoint of more efficient engines, reduction in friction in drive train and tracks, reducing unnecessary weight and I might add, even providing waterproof storage boxes for storage of crew baggage. (Present boxes are not watertight and when clothes become wet, the tank crew will operate the main engine to dry out their belongings.)

(4) *Mufflers:* Our present muffling system occupies too much space and requires too much metal to construct. Several small space-saving mufflers have been used, but their main disadvantages are that a blue flame extends too far out of the muffler and they are too noisy.

(5) *Battery:* Present tank batteries are rather delicate for field use as the outer casing breaks too easily—especially in cold weather. We need a rugged, waterproof battery that will not "boil" over,

Men of a tank platoon test fire weapons on M46 tanks at Taegu

and with the ability to provide sufficient energy for starting in sub-zero climates when provided with battery heater.

Operational

(1) *Crew Comfort:* This requirement should be approached with caution. Too much crew comfort costs a great deal. Too little brings on fatigue and can make the crew feel that they have been neglected. (The British provide an electrical outlet for heating tea in some tanks and this is an example of a "luxury" item that probably pays for itself.) In the Patton Tank, the tool and accessory boxes, located on the fenders are not waterproof and no provision is made for the storing of the crew's few essential items of clothing other than to tie it to strap loops on the outside. Thus, when rain or snow is encountered, items in the tool chest as well as clothing, etc., tied to the outside of the turret, become wet. To dry out the material, a 12-cylinder engine is run so that the exhaust heat can be utilized for drying purposes. This is an example of providing insufficient and ineffective items for crew comfort. In the long run, waterproof tool chests and storage space for clothing would pay for itself in the saving of gasoline alone.

(2) *Winterization:* Operations under extreme cold temperatures have always presented a problem which should be constantly under consideration for improvement. Our winterization equipment is expensive and does not dispense the heat to the proper areas. Efforts should be continued to improve this vital type equipment. In some cases, primitive methods (blow torch, fires, etc.) have been utilized to start the tanks.

(3) *Evacuation Equipment:* Terrain and roads throughout Asia make recovery of tanks, extremely difficult, so our big and cumbersome recovery equipment operates under very handicapped conditions. In the combat zone, tanks—like trucks—should be able to pull one another for a considerable distance over the normal type of roads encountered. Our present tanks are not designed with that in mind,

One type of tank operation: The tank is being used for indirect field artillery fire, and has been dug in to obtain maximum elevation

but steps should be taken to obtain sufficient power (torque) in low range to make every tank a potential recovery vehicle.

(4) *Napalm:* This new type of bombing has proven to be a most potent weapon in many respects. The Air Force claims that Napalm is a most effective weapon, while other military people seem to question their claims. The subject is presently being tossed back and forth with no concrete answer. Tests are presently being conducted that should give an acceptable solution. Like any other type of bombing, however, it must be accurate to be effective. This mixture of gasoline and a chemical produces a jelly-like substance which ignites and burns when exploded. The resulting fire burns the rubber off of the suspension and can cause a more serious conflagration if the proper areas are hit. This may lead to the use of fireproof substances throughout the suspension and mechanical means of sealing the engine compartment for short periods.

Conclusions

In this emergency, large quantities of military type automotive equipment are being manufactured. The need is great, but there are still basic considerations that should be followed. Six considerations are in my mind at the present time but many more no doubt exist. Although they are not new, I think that it would be worthwhile for personnel in the SAE and Ordnance, who are concerned with military automotive equipment, to keep these items in mind. Let's look at these one at a time.

a. *Simplicity:* This term has many meanings, but essentially it means the vehicle should be easy to operate, easy to maintain, utilize standardized components and contain only the essential equipment necessary for proper functioning. As production figures mount, it is doubly essential that all nonessentials be eliminated so that the overall cost of the vehicle is lowered and resources saved. A good example of simplicity is our present automatic transmission—it is easy to operate and maintain from a field standpoint and, of course, is essential.

b. *Adaptability:* A military vehicle should be capable of rapid adaptation to various climates, types of terrain and fording operations. This includes winterization, waterproofing, protection from dust and ability to operate in varying areas throughout the world. By adaptability is also meant standardization on basic vehicle types for all possible uses so that the number of vehicle types required can be reduced. Don't forget that this also includes spare parts interchangeability—adapting the same part to as many vehicles as possible.

c. *Efficiency:* Efficiency means getting the most out of a product from the smallest possible input and, in a sense, it means reliability. Improved fuel economy, mobility and life of components will naturally result in higher efficiency and better reliability. Korea has definitely proven that proper testing can eliminate 90% of the deficiencies in a product prior to issue. During my observations, I found very few new type deficiencies not already discovered in testing at Aberdeen Proving Ground and which Service Boards had taken steps to correct. Thus, if a product is adequately tested in the laboratory, installed in the vehicle, tested and necessary changes made, you can expect very good efficiency in the field.

Once these three considerations have been integrated in the development of a vehicle, it is necessary to consider three additional factors. Let's take a look at these other factors which are normally a military function but in which even here we are ably assisted by civilian industry.

d. *Operation:* Most important in this respect are proper training programs, preparation of operational publications, inspection of operations and the reporting of new types of deficiencies so that the product can be continually improved. Proper operation calls for proper training. This is a never-ending problem to everyone in the military service. Personnel are constantly changing. Barbers and clerks drafted into the Army must at times be utilized as operators and mechanics since demand for technically trained men exceeds the supply available and equipment is becoming more complicated every year.

Many automotive manufacturers are conducting very fine schools to teach military personnel how to maintain their equipment. Most of these schools are established to accommodate just one class of students who serve as instructors at their particular stations when they return. Therefore, they must be well organized and conducted with emphasis on trouble shooting and practical field repair. If the students are given too much theory in a special short course, they will be unable to analyze failures when encountered in the field. Korea proved that practical training is the most important type.

The weakest link in the training program at present is in testing and trouble shooting electrical equipment. Experienced automotive electricians are scarce in the Army and, therefore, training in this field must be as simplified and practical as possible.

e. *Repair:* Closely allied with operations is the repair of the vehicle. Adequate tools and testing equipment, clearly written technical publications and establishment of maintenance procedures must be considered and become a reality before the vehicle is issued to troops.

In many instances use of field representatives will greatly increase the initial acceptance of a product.

f. *Distribution:* Here the Ordnance Field Service enters the picture, as they must inspect, store and issue the item. They must also insure that proper preserving methods are employed to protect equipment during shipment and in storage. Most important is the accumulation of parts mortality data so that adequate stocks can be procured and issued to keep the vehicles operating.

Summary

I want to leave with you a clear impression of our appreciation of the teamwork that exists between SAE and Ordnance. SAE has rendered to Ordnance splendid cooperation, coordination and support. These combined efforts have produced automotive equipment which has no competitor. If continued, we may rest assured that the future will see even greater improvements.

Design and Production of

PLANETARY GEARS

for Automatic Transmissions

EXCERPTS FROM PAPER BY

D. T. Sicklesteel, Detroit Gear Division, Borg Warner Corp.

• Paper, "Planetary Gears For Automatic Transmissions," was presented at SAE Annual Meeting, Detroit, Jan. 8, 1951.

RAPIDLY increasing use of planetary gearing in automatic passenger-car transmissions emphasizes the need for well-designed gearsets and rigidly controlled production methods for making them.

Design of a planetary gearset for an automobile transmission is based upon vehicle type and weight, engine torque and horsepower, tire size, axle ratio, and torque converter or fluid coupling performance (if used). Before actual design work starts, the number of speeds, approximate ratios, and number of automatic shifts should be decided. Final selection of the type of gearset to be used depends on the designer's solution to some of these problems:

1. What kind of shifts—crossover, takeaway, and so on.
2. Type and number of clutching and holding elements.
3. Methods for supplying oil to clutches, bands, and lubrication.
4. Provision for adequate support of brake drums.
5. Mainshaft and output shaft size.
6. Practical ratio limitations of various types of planetary gearsets.

Fig. 1 shows the speed reduction ratios theoretically available in a simple planetary gearset having a sun gear, ring gear, planets, and a planet carrier. (See Fig. 2.) The ordinate is plotted as the ratio of the sun gear size to the ring gear size. Extreme ratios near the top and bottom of the curves are impossible of attainment because of practical limitations on the size of the sun gear, ring gear, and planets. For this reason all the planetary gearsets now in production lie in a well-defined band between 0.41 and 0.61 sun gear to ring gear ratio. (See Fig. 3.)

After the type and general arrangement of the gearset has been decided, actual calculation of the gears begins. A unique method is used in an attempt to design the gears to service and life expectancy required. It is based primarily on a method for calculating gear teeth in bending, bending fatigue curves published by Almen and Straub,[1] and compressive stress fatigue data by Buckingham.[2]

A short summary of the steps in this rather involved and detailed calculation is:

1. Estimate full-throttle life requirements. (For a three-speed automobile transmission—140 miles in first gear and 420 miles in second.)
2. Using axle ratio and tire size, convert miles of life into total number of stress cycles required. (When gears are used in more than one ratio, second-gear cycles are converted to low-gear cycles and then added to the low-gear cycles required.)
3. Calculate conventional *P-V* values for each mesh. (Surface compressive stress times rubbing velocity at start and finish of contact.) *P-V* values are not found directly. Rather a pitch contact ratio is assumed and the *P-V* values equated. This gives a direct solution for the gear outside diameters, independent of the face width, and results in long and short addendums of the pinion and gear teeth, respectively.
4. Lay out gear teeth to determine tooth bending factors and, by increasing the pinion tooth thickness and decreasing the gear tooth thickness, arrive at bending strength values which satisfy bending fatigue requirements set up in step 2.
5. Solve step 4 for the required face widths and

[1] "Factors Influencing the Durability of Automobile Transmission Gears," by J. O. Almen and I. C. Straub in "Automotive Industries," Sept. 25, 1937 and Oct. 9, 1937.

[2] "Manual of Gear Design," by Earle Buckingham in "Machinery."

determine the actual *P-V* values and tooth thicknesses.

Two or three trials usually are made before arriving at the final design. The aim is to have every gear working to the limit, thus making maximum use of the material. It is felt that this method results in the strongest and smallest gearset which will meet requirements. And it offers a direct mathematical solution, rather than a cut-and-try one, to such questions as, "What should the arcs of approach and recession be?" and "How long should these gears run?"

No safety factor is used for the bending fatigue curves. Reasons for this are: (a) considerable improvement in manufacturing practices since the curves were published, (b) reduced shock loading with fluid driving members, (c) and adoption of crown shaving, which reduces stress concentration at the ends of the teeth. Proof that this practice is justified can be found in the fact that, during the development of the Studebaker automatic transmission, cars were run for 1500 miles at 30 mph, full throttle in low gear, with a towed load of 4600 lb without evidence of gear tooth distress.

Gears for the Studebaker automatic—calculated according to the above method—have some unique features that do not appear from casual examination.

The front set has a 42-tooth sun gear, 13-tooth planets, and a 69-tooth ring gear. But, $42 + 13 + 13 = 68$ does not match with the 69-tooth ring gear. The gears are 16 normal pitch, 20-deg pressure angle, and 20-deg helix angle. Planets and ring gear operate on so-called standard centers while the planets and sun gear operate on spread centers.

The planets and sun gear are cut with long and short addendums on enlarged blanks. This is done to eliminate undercutting of the planet, provide adequate contact ratio, and reduce both bending and surface stresses. Planet tooth thicknesses are increased and sun gear tooth thicknesses decreased from standard to provide uniform bending fatigue life. The ring gear is cut deeper to accept the thicker planet teeth. Rear unit gears receive similar treatment.

As can be seen readily, these gears are far from standard and one might expect them to be noisy. However, comparison tests with gears designed from a handbook—having standard addendums, tooth thicknesses, and centers—proved otherwise. No appreciable difference in noise level between the two sets was observed.

Front and rear ring gears and the front sun gear are made from forgings of SAE 8620 H steel. These forgings are prepared for machining by cycle annealing in a Ryan Sculley twin furnace unit. This cycle features a 1675 F austenitizing temperature zone, a direct air blast cool to 1200 F, and a transformation zone held at 1200 F.

Planet pinion gears are made of SAE 8620 H bar stock.

Hardening of all of these gears consists of carbonitriding to a case depth of 0.015–0.025 in., oil quenching, and tempering at 325 F. The ring gears are carbonitrided in two Holcroft batch-type furnaces which incorporate an enclosed vestibule quench. This type of quench produces parts which require a minimum of cleaning.

The rear sun gear serves a dual purpose in that it combines a gear on one end and a freewheel race on the other. It is made from SAE 8640 H steel tubing, stress relieved. After machining, the parts are carbonitrided to a case depth of 0.015 to 0.020 in., oil quenched, and tempered at 400 F. This part is also carbonitrided in the Holcroft batch-type furnace. The freewheel race end of the part is then induction hardened to a depth of 0.060 to 0.090 in., and is tempered at 325 F. Equipment for induction hardening was designed and built by Allis-Chalmers specifically for this part, and incorporates a 20 kw radio frequency generator. The part is rotated and moved progressively through the coil during heating and quenching.

Gears are produced on the following machines:

Planet pinions are roughed out from bar stock on 6-spindle Conomatic screw machines, bored and faced on Excello double-spindle boring machines, and hobbed three at a time on Cleveland 8-spindle rotary hobbers. Both ends of the acute corners of the teeth are chamfered on Modern burring machines and crown shaved on Michigan Tool diagonal underpass rotary shavers with automatic loading

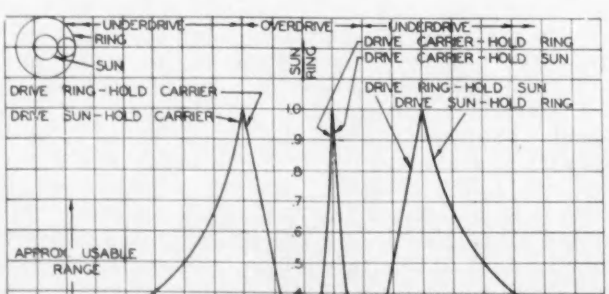


Fig. 1—Ratios available in a simple planetary gear set

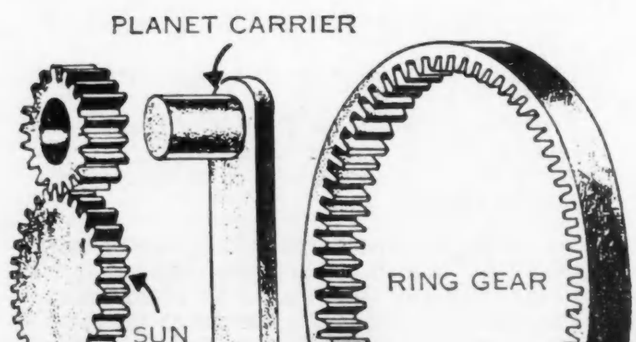


Fig. 2—Simple planetary gear set

attachments. After heat-treatment pinions are grit blasted in an American Wheelabrater Tumblast machine and the bores finish honed.

Needle bearing bores in both front and rear planet pinions are honed to 0.0005 limit on the diameter with taper not to exceed 0.0003. This is necessary to prevent the pinions from developing excessive end thrust. Theoretically, planetary pinions have no end thrust but, practically speaking, excessive end thrusts can be produced if the hole is tapered. The bores are also held concentric with the pitch diameters within 0.002 and the out-of-round of the bore is limited to 0.0002 maximum. Maximum allowable finish of the honed bore is 10 micro-in.

Thrust surfaces of the front pinion (which is run directly against the carrier without thrust washers of any kind) are ground to 20 micro-in. maximum finish because of the small thrust surface, while those of the rear, being larger, are precision turned to 40 micro-in. maximum finish.

Pinion thrust faces are held square with bore within 0.001 total indicator reading. Actually, they average 0.0003 because of precision turning employed in manufacture.

Crown is specified as 0.0008 to 0.0012 in length of face, the front pinion being 13/16 and the rear pinion 15/16 in. long.

Both pinions are cut to true lead in the green, as no unwinding occurs during the heat-treatment. The 19-tooth rear planet is cut 0.0005 undersize over pins and the 13-tooth front planet is cut 0.0007 undersize over pins to compensate for growth in heat-treatment.

The front sun gear is roughed out for forgings on Acme-Gridly and New Briton 6-spindle chucking machines. The clutch seal groove is cut on an Imp Lo-Swing automatic lathe and the piece is furnished on Excello 2-spindle precision boring machines. Rivet and oil holes are drilled in a Buhr 3-way drilling machine. Gear teeth are rough cut in a Cleveland 8-spindle rotary hobber and chamfered on one end in a Modern burring machine. The teeth are finished on a Michigan Tool diagonal underpass rotary gear shaver and, after heat-treatment, pilot diameters and flange faces are ground on Landis & Bryant grinders.

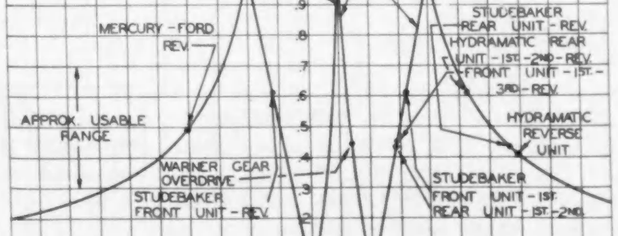


Fig. 3—Simple planetary gear sets now in production

The rear sun gear is rough and semi-finished turned in an 8-spindle Conomatic. The bore for the bushing is broached on a Colonial broach, after which the thrust faces and outside diameters are finished on 2-spindle Excello precision boring machines. Oil holes are put in on a Kingsbury 6-spindle drilling machine. The teeth are rough cut on a Fellows planetary gear shaper and the teeth chamfered on one end only on a Modern burring machine. Teeth are finished on a Michigan Tool diagonal underpass rotary gear shaver. After heat-treatment bushings are pressed in and bored on 2-spindle Excello precision boring machines. The freewheel diameter is ground on a Cincinnati grinder and the thrust surfaces on each end are ground on a Heald rotary grinder.

Both sun gears are cut to 0.0002 plus lead to compensate for a slight unwind in the heat. The 30-tooth rear sun gear is cut to 0.0018 undersize over pins and the 42-tooth front sun gear is cut 0.0027 undersize over pins to compensate for heat-treat growth. Pitch diameters held to 0.002 maximum runout with bores and ground diameters.

The front ring gear is rough turned from forgings on 8-spindle Bullard lathes. The hole is broached, after which it is semi-finished and finish turned on Lo-Swing lathes. Bores, thrust faces, and Gleason Press locating surfaces are finished on Excello precision boring machines. Splines are hobbed on a Cleveland 8-spindle hobber and the spline ends are chamfered on a Sheffield spline burr. Internal gear teeth are cut on Fellows gear shapers after oil holes are drilled. The teeth are finished on a Michigan Tool rotary gear shaver. Following heat-treatment the needle bearing outside diameters are ground on a Norton grinder and the needle bearing inside diameters are ground on a Bryant hole grinder. Piston ring grooves are ground on an Excello groove grinder and a J & L automatic form grinder.

Except for minor details, processing of the rear ring gear is the same as for the front ring gear.

Both ring gears are cut with 0.0005 plus lead to compensate for unwinding during the heat-treatment. The gears are also cut 0.001 oversize inside pins to allow for shrinkage during the Gleason press quenching operation. Pitch diameters are held to 0.002 runout with ground bearing diameters and bushing bores.

Since both front and rear carriers are similar, the processing will be described for only the rear. The carrier is rough turned from forgings on 8-spindle New Briton chucking machines. The spline is broached on a Colonial 2-station pull broach and additional rough turning is done from arbors on Gishold automatic lathes. Pinion shaft holes are drilled on a Cincinnati-Bickford drill. Pinion slots are rough milled from the solid on a Cross special machine and finish milled on a Heald special machine. The sharp tabs left at the inside edges of the slots are removed by plunge milling on a Sheffield special machine. Thrust faces are precision turned on 2-spindle Excello boring machines, after which the pinion shaft holes are bored on Excello boring machines. Both carriers are balanced within ½ oz-in. on Gishold Dynetric vertical balancing machines.

Planet pinion shaft bores are held to 0.002 limit

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Instruments Observing

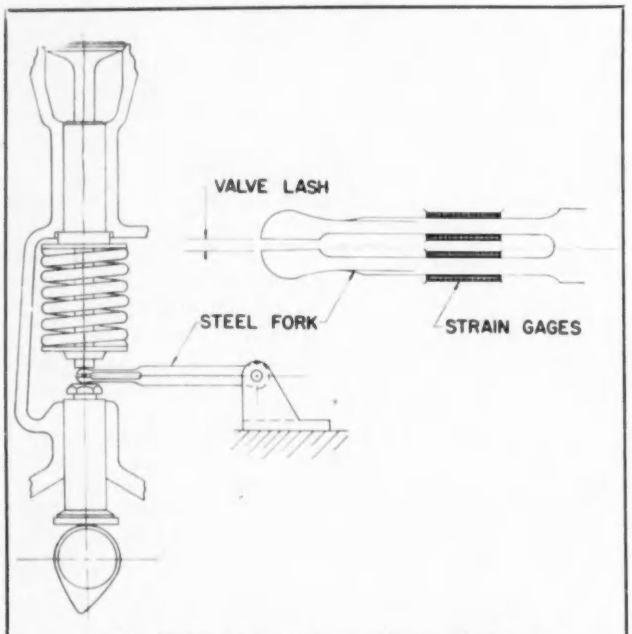

Fig. 1—Working diagram for strain gage lashometer

The Strain-Gage Lashometer

EXCERPTS FROM PAPER* BY

A. E. Cleveland, Engineering Research Dept., Ford Motor Co.

* Paper, "Strain-Gage Method of Determining The Running Lash of L-Head And Overhead Engines," was presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 8, 1951.

THE strain gage lashometer, developed to study operating lash variations in L-head engines, consists of a two-prong fork which fits between the valve and lifter. The base of this fork is pivoted in an anchor in such a manner as to permit the free end to travel up and down with the valve. (See Fig. 1).

Since the spring load of the fork is much lower than that of the valve spring, the prongs of the fork close as the cam takes up the valve lash and remain closed until the valve is seated. The fork returns to its normal open position when the lifter follows the cam into the unloaded base circle. As the valve expands or contracts relative to the cylinder block, the takeup distance between the prongs becomes greater or less, corresponding to the lash.

This takeup distance is converted into elastic strain and transmitted to four strain gages mounted, one each, on the tension and the compression side of each of two prongs of the lashometer fork. These four strain gages, wired in a conventional bridge circuit, provide the voltage (of unbalance of the bridge circuit) to activate a brush oscillograph and amplifier recording system. (See Fig. 2). Amplitude of the oscillograph trace, therefore, is directly proportional to the bridge unbalance which, in turn, is proportional to the valve lash. (See Fig. 3).

Temperature compensation, most important in any strain gage measurement taken over a wide range of engine operating conditions, is automatically provided by the alternate tension and compression location of the strain gages and the balance of the bridge circuit.

Observations from multiple lashometers, made possible by a special circuit and switching arrangement, prove very useful in saving the time of shifting the instrumentation from one valve to another.

Fig. 4 shows the effect of engine speed on intake and exhaust valve lash in one L-head engine at wide-open throttle. (In this and subsequent curves, the vertical axis is a measure of change of valve lash from an initial lash setting, which for comparative purposes is designated as zero lash point. Changes in the negative direction, below the zero line, indicate a decrease of valve lash while changes in the positive direction indicate increases.) Intake valve lash increases as an approximate linear function of speed; exhaust valve lash decreases as an approximate reciprocal function of speed.

The effect of road load operation over the speed range is also shown in Fig. 4. As would be anticipated, deviations from initial lash are smaller in magnitude in both intake and exhaust to a degree somewhat less than the difference between road loads and wide-open throttle. And while exhaust valve lash decrease becomes the same as wide-open throttle at the higher road loads, intake valve lash remains substantially less even at 3500 rpm. This is probably because intake valve lash increase, caused by greater block expansion than valve expansion, is accentuated by the valve cooling of the richer full throttle fuel mixtures.

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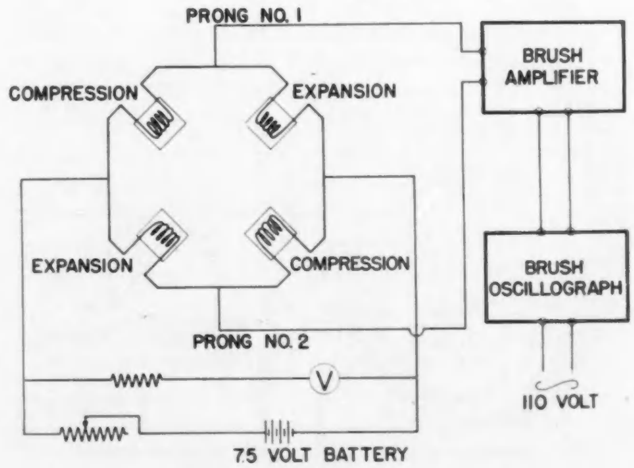

Fig. 2—Electric circuit for strain gage lashometer

Used for Valve Lash

The Lashograph— A Mechanical-Optical Device

BASED ON PAPER* BY

E. B. Etchells, Chevrolet Motor Div., GMC

* Paper, "The Lashograph—An Instrument For Observing Valve Lash In A Running Engine," was presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 8, 1951.

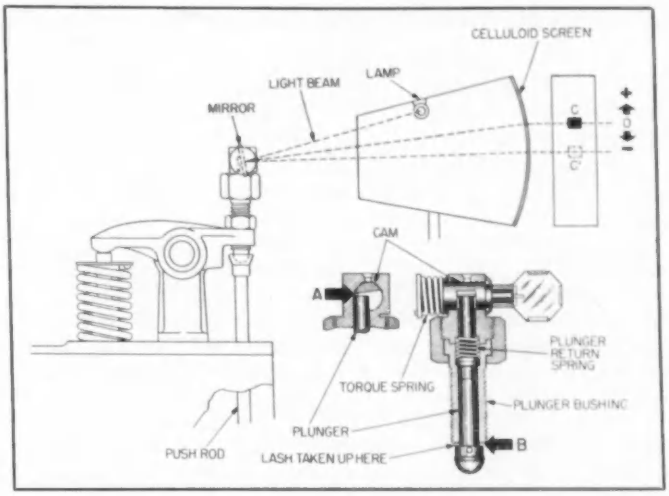

Fig. 1—Basic parts of the mechanical-optical lashograph

THE lashograph, a mechanical-optical device, indicates operating valve lash with high accuracy at speeds up to 4000 rpm.

Basic parts of the lashograph are shown in Fig. 1. The instrument screws into the valve rocker arm in place of the regular adjusting screw. And the round end of the plunger fits into the conventional push rod. The cam is held against the plunger at A by the action of a torsion spring. A small beam of light, reflected from the mirror to a nearby translucent screen, permits observation and measurement of the valve lash. (The mirror assumes angles which depend on existing valve lash.)

When the engine is running, expansion or contraction in the valve train cause the cam and mirror assembly to deflect from its original position. The light beam is deflected rapidly when the valve opens. But it is clearly defined for more than 180 deg of camshaft rotation (during the period when the valve is closed). And variations from its initial position are easy to determine.

Before taking any readings it is necessary to provide the valve mechanism with sufficient clearance to insure complete closure of the valve under all operating conditions. The lashograph is set to read zero with this clearance, and subsequent changes from zero indicate changes in valve lash.

The point marked C is the zero setting on the scale. It is set with the tappet on the cam base circle, with the engine cold. Calibration is made by inserting feeler gages between the valve stem tip and the rocker arm, which turns the mirror, deflecting the light beam to C′. The distance between C and C′, then, is the amount of valve lash originally provided.

Vibration, which made readings at high speeds difficult with the previous instrument used, is reduced by the plunger return spring. This spring not only steadies the cam action, but also helps to overcome friction within the plunger bushing, assuring greater accuracy in the instrument.

Another feature of the lashograph is the shoulder provided at the base of the plunger to remove the load from the cam when the valve is opened. Only enough space is provided between the shoulder and the plunger bushing, at B, to account for variations in lash when the valve is closed.

Typical results of tests made with the lashograph are shown in Figs. 2, 3, and 4. To interpret these curves correctly, it is necessary to know the engine operating conditions under which they were obtained.

In Figs. 2 and 3, the idle warm-up cycle began at room temperature with 1 min at 400 rpm, no load. The speed was then set at 1400 rpm and allowed to creep up to 2100 rpm, where it was held until the oil temperature reached approximately 190 F. Thereafter, the water temperature was maintained at 185 F. (This portion of the test consumed about 20 min.) Engine speed was then reduced to 400 rpm

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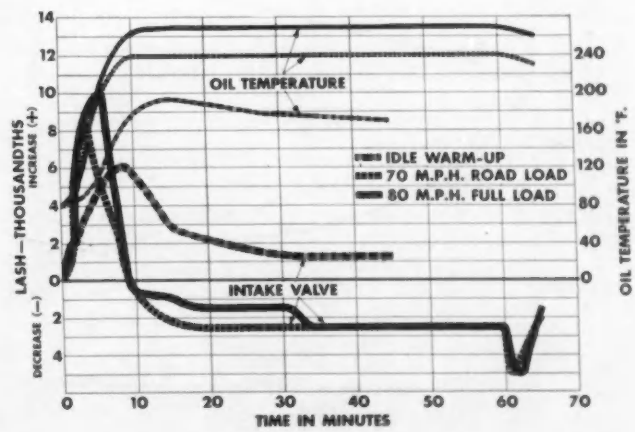

Fig. 2—Intake valve lash change for idle warm-up, road load, and full load tests

The Lashometer - continued

Fig. 5 shows a study of the variation of exhaust valve lash during warm-up as a function of time at two different rpm wide-open throttle. (Sump oil temperature and cooling-water outlet temperature are shown in bar graph form as a matter of supplementary information.) The tendency for initial valve lash change to over-shoot the subsequent stabilization point did not show up in these studies. At both speeds, however, there is a slight negative slope or minimum point at approximately 2 min after start. It is entirely possible that under certain operating conditions this minimum would be more greatly accentuated, although it was not shown in the scope of our tests.

Intake valve lash variation as a function of time (see Fig. 6) shows a decided maximum point for 3600 rpm at approximately 2 min, a minimum point at approximately 6½ min, and a gradual stabilization after 12 min. At 600 rpm, the maximum is attained again at about 2 min and retained until approximately 8 min when it falls off to its stabilization point.

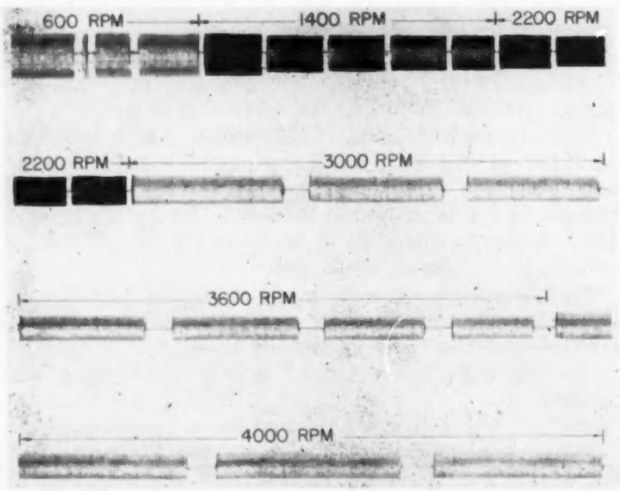

Fig. 3—Amplitude of oscillograph trace is proportional to valve lash

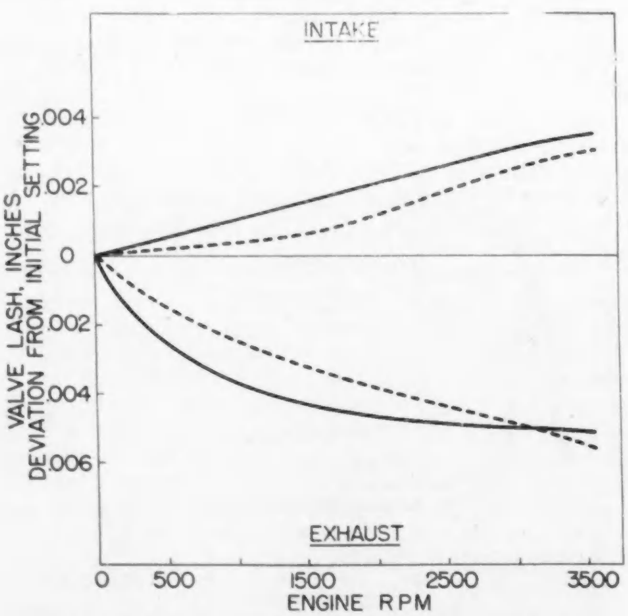

Fig. 4—Valve lash variation is a function of engine speed and load —WOT - - - Road Load

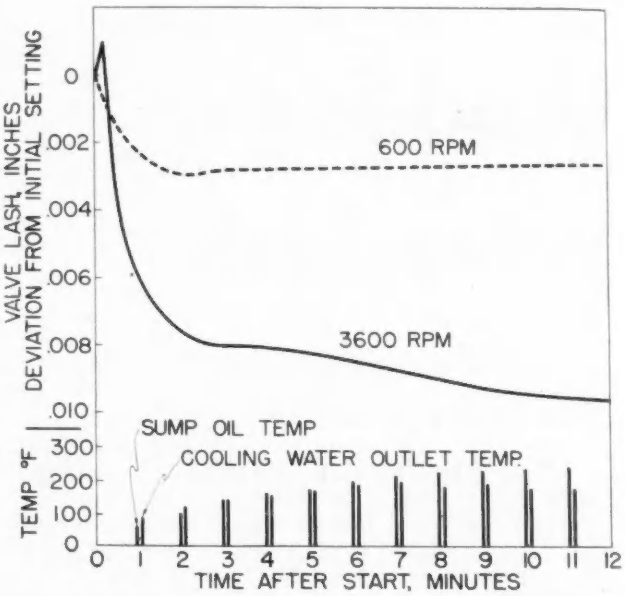

Fig. 5—Exhaust valve lash variation during warm-up for L-head engine —constant speed, wide open throttle

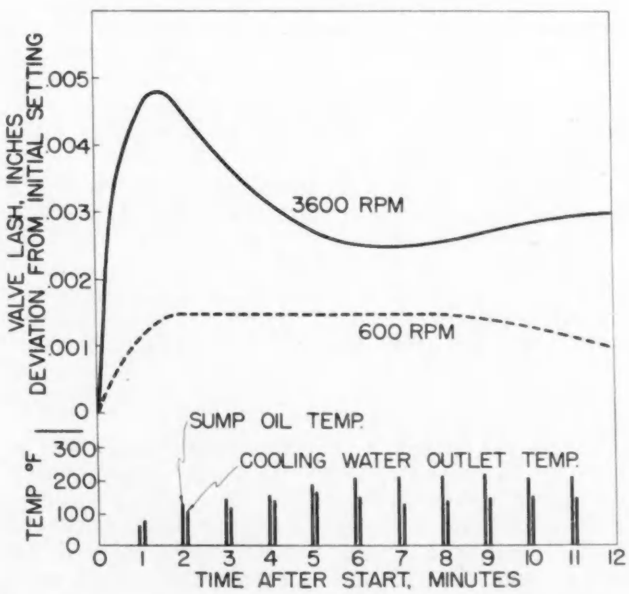

Fig. 6—Intake valve lash variation during warm-up for L-head engine —constant speed, wide open throttle

These variations are the result of the differing time rates of temperature rise in the valves and cylinder block. Rapid rise of temperature within the block at 3600 rpm, and the cooling effect of the gases through the intake valve at 3600 rpm, produces a pronounced peak differential of expansion at 2 min. The lower heat rejection to the block and less cooling at the valves due to intake gases results in a less pronounced peak at 600 rpm.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

he Lashograph - continued

d held there until valve lash became stabilized. ie whole cycle took about 45 min.

In the road load and full load tests of Figs. 2 and the engine was first run at 400 rpm for 1 min, then der conditions corresponding to the indicated ad speeds and loads for the balance of 1 hr. At ie conclusion of these runs, engine speed was re- uced to 400 rpm for 5 min.

In Fig. 2, intake valve lash increases sharply at rst, as the cylinder block warms up, then decreases s the oil temperature rises. After the initial in- rease, there is only a small decrease in valve lash, even at high speeds and loads. Note, however, the harp decrease in lash on the road load and full load runs, when the engine speed is cut to 400 rpm.

Except for the idle warm-up cycle, the exhaust valve lash changes in Fig. 3 are all negative. All the runs show similar characteristics. Valve lash first decreases, due to exhaust heat in the valve, then increases as the cylinder block warms up. Finally, it decreases to a stabilized value as the temperature of the valve and the oil rise. Note the sudden increase in valve lash, caused by the rapidly cooling exhaust valve, when the engine speed is reduced to 400 rpm at the end of 1 hr.

Fig. 4 shows a composite type of lash change test, in which results for the idle warm-up, 30, 50, and 70 mph road loads, and 80 mph full load were obtained in one continuous run. Except for the additional 30 and 50 mph road load runs, the conditions in this test were identical with those in Figs. 2 and 3.

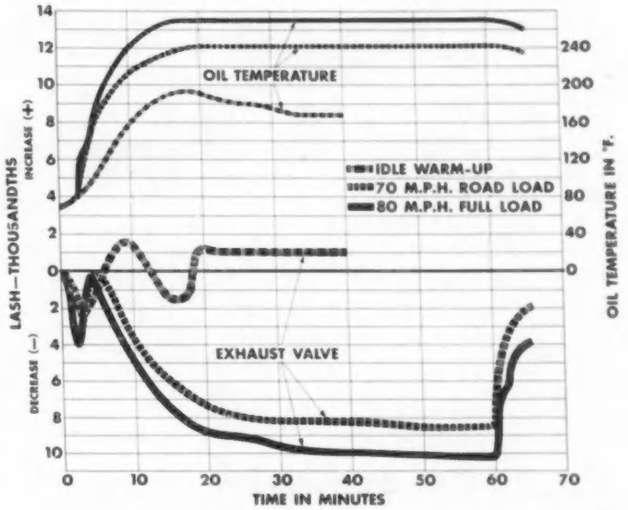

Fig. 3—Exhaust valve lash change for idle warm-up, road load, and full load tests

There are numerous types of cycling tests that may be used to determine valve lash changes in a running engine, but, in general, the ones described are found to be the most useful.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

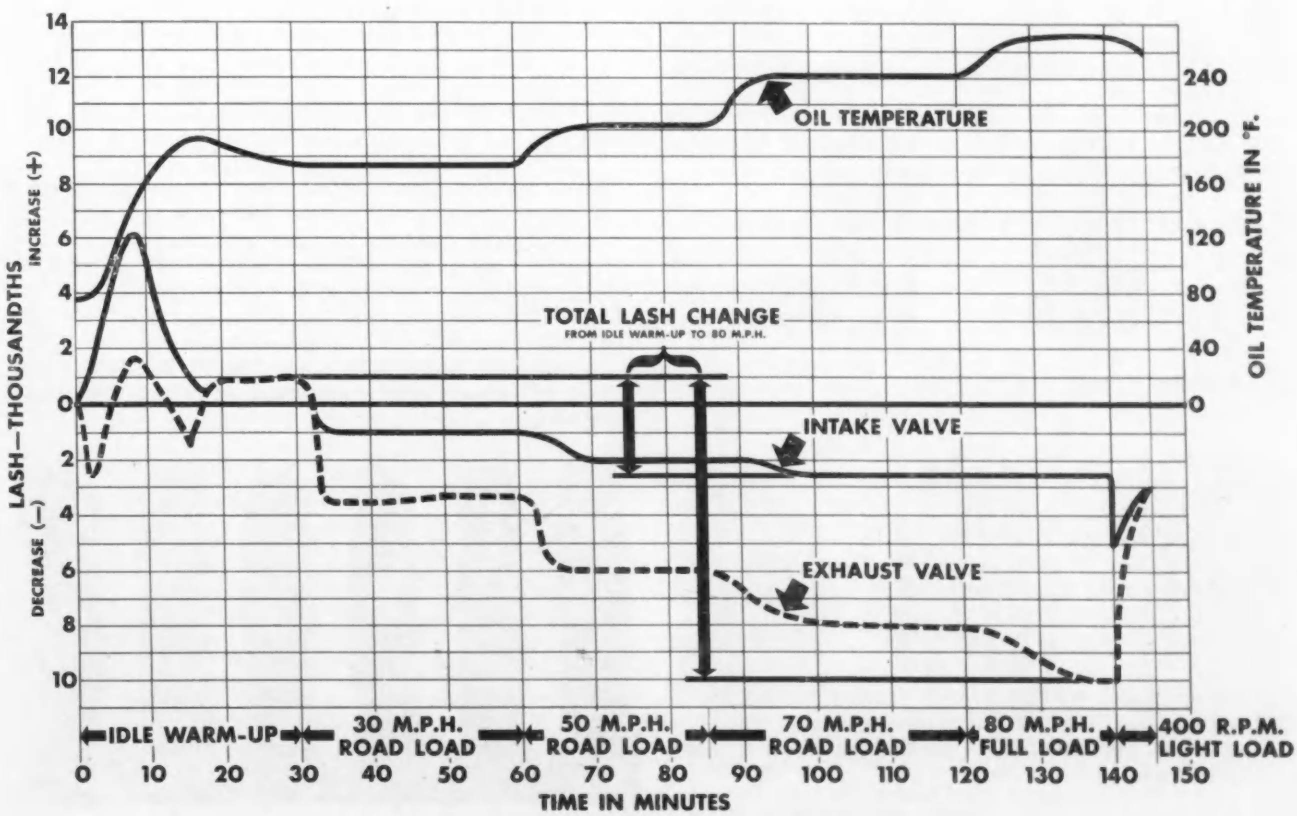

Fig. 4—Intake and exhaust valve change for continuous run

Tire Engineers Face

TIRE engineers face challenging problems. Public demand continues for reduced tire noise, improved ease of car handling and riding comfort, and increased tire wear and durability. But de-

Ease of Car Handling

BASED ON PAPER* BY

J. J. Robson

Firestone Tire & Rubber Co.

TRACTION is an essential ingredient in both safety and ease of car handling. This is well-illustrated by the fact that skidding caused 49,860 deaths or injuries in 1949.

Tire manufacturers, therefore, constantly try to get better traction. But they are handicapped by the present trend of automobile design and the need to achieve better traction without sacrificing other desirable tire qualities.

Tire engineers use these two different approaches. Attempts are made to:

- Increase the natural friction between the tread rubber and the road;
- Improve the mechanical action of the tread design.

Different types of rubber tread stocks increase the natural friction between the tire and the road, as shown in the following table:

Stopping Distance, Various Tread Compounds

	Packed Snow Stopping Distance From 25 Mph Ft.
Rubber Tread A	139
B	140
C	143
D	146
Cork Dust	137
Grass Pellets	127
Coarse Walnut Shells	125
Hard Coal	113
Hard Rubber Particles	108
Crepe Rubber	83
Note: Dry Pavement Stop	32

Most of these special treads however, especially those with the foreign material approach, cause a loss of wear not acceptable to the public for year-round service.

*Paper, "Safety and Ease of Car Handling," was presented at SAE National Passenger Car, Body, and Materials Meeting, March 7, 1951.

Aggressive tread designs, involving various types of cuts and perforations, also improve tractive ability. Some of the designs shown in Fig. 1 give very good traction. However, they are unable to meet exacting requirements of automobile engineers because of excessive noise and uneven wear.

Traction depends directly on the amount of tire load and varies greatly with these road conditions:

Coefficient of Traction

Dry Pavement	0.8 -0.9	
Wet Concrete	0.5	
Wet Smooth Asphalt	0.4	(Can drop as far as 0.15 when covered with film.)
Hard Packed Snow	0.1 -0.3	
Ice	0.07 -0.10	

The present trend of automobile design toward increased power output and forward movement of the center of gravity further complicates the tire engineer's problem. This combination of greater power and less weight on the driving wheels make it increasingly difficult to obtain good rear tire traction.

Automobile engineers are urged to recognize the effect of these factors on traction when designing new cars.

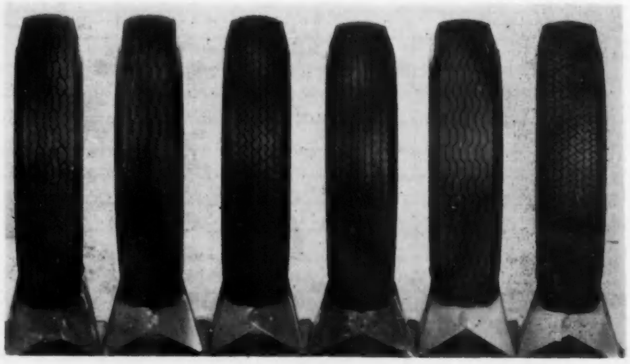

Fig. 1—Experimental tires designed to increase traction

a Challenge

sign changes made to improve one of these qualities often weaken or undermine another. Designing better properties into tires thus presents an interesting but difficult problem for tire engineers.

Tire Noise

BASED ON PAPER* BY

W. F. Perkins and W. F. Billingsley

B. F. Goodrich Co.

GREATLY improved roads and low engine-body noise make present-day tire noise an important aspect of tire design. Determining the place of tire noise in the overall vehicle noise picture and the establishment of satisfactory noise standards is an extremely difficult undertaking. The problem resolves itself into deciding what sounds are disagreeable and what intensity level can be tolerated. Tire engineers then try to reduce this noise without decreasing tire anti-skid, stability, and riding qualities.

Tire noise may be classified into four general types:

- Hum or rumble on smooth straight-away.
- Squeal on turns or braking.
- Shock noise (Seam bump noise).
- Thump.

Hum or rumble is largely a function of tread design pattern. This type of noise is reduced by (1) using smaller design-pattern elements (Fig. 2) to reduce impact force of the individual element on the pavement, (2) sizing elements so that tone produced is less disturbing, and (3) varying length of design elements around the tire circumference so as to set up sound-wave interference patterns.

Squeal on turns and braking, caused by design elements being set in vibration by slippage on the pavement, are reduced by changing (1) surface texture of tread to increase coefficient of friction, (2) tread compound to produce a deader stock, (3) dimensions of tread elements.

Seam bump noise depends on tire shape, particularly the area in contact with the road. Tires which make long oval contact traverse seam bumps with less noise and shock than tires with relatively square-ended contact. (Fig. 3.)

"Thump," which may be audible or detected by a poor or rough ride, is generally produced by an abrupt change in the rolling radius of the tire. Changes in rolling radius are brought about by any one or combination of a large number of factors, some controllable during tire manufacture, some inherent in the method by which tires are manufactured. A partial solution to this noise problem is more care and attention to manufacturing details.

Search by the tire industry for a quiet tire with satisfactory anti-skid has led to development of literally thousands of variations in tread patterns, tread treatments, and compound changes. Many of these tires meet anti-skid requirements but are not generally acceptable because of relatively high noise level.

It is apparent, however, that a fairly large section of the driving public is willing to accept higher noise levels if increased anti-skid can be obtained. And quite possibly present noise level standards may be exceeded in the future if continued demands for safer vehicle operation are to be met.

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Fig. 2—Typical tread patterns designed for noise suppression

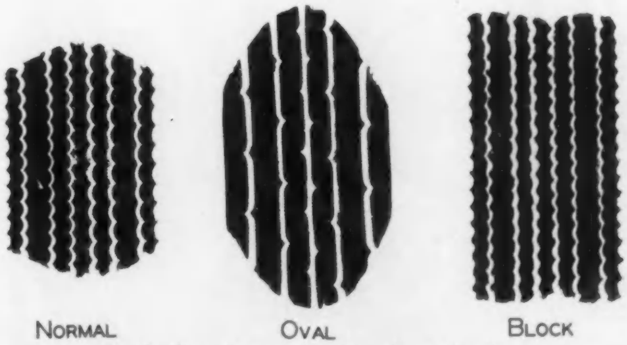


Fig. 3—Seam bump noise depends on tire shape

*Paper, "Tire Noise," was presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 7, 1951.

Tire Wear and Durability

BASED ON PAPER* BY

A. W. Bull

United States Rubber Co.

TIRE wear and durability are of prime interest to both tire engineers and ultimate users. They measure these qualities by:

- Ability of tire to wear out rather than fail from blowout or other cause.
- Number of miles delivered before the tread is worn smooth.

Fortunately, a large percentage (more than 90%) of current passenger car tires wear out without experiencing accidental, heat, or fatigue failure. And when failures do occur, most of them take place after the tire is half worn.

Tire overloads cause a rapid increase in both fatigue and heat failures. Even accidental failures, such as rupture or rim bruise, are more likely to occur when the tire is overloaded.

Tread wear is affected by many variables. Condition of the vehicle, terrain and climate in which it is operated, driver's habits, load distribution, and inflation pressure all play an important part in determining tire mileage obtained.

The driving habits of the car operator are the most important factor in determining tire mileage. Easy drivers get far better mileage from a set of tires than hard drivers.

Annual surveys made in different sections of the country indicate that climatic and geographic differences have an affect on tread wear. Fig. 4 shows distribution curves for estimated anti-skid mileage in Los Angeles and Detroit for the same model car, equipped with 6.70-15 (U.S. Royal Air Ride) tires. (Percentage frequency is plotted in 2000 mile intervals. For example: 8% of the Los Angeles cars obtained tire mileages between 12,000 and 14,000 miles.)

The arithmetic average for Detroit was 30,300 miles, as compared to 18,750 in Los Angeles, a ratio of 100 to 62. This difference, which occurs year after year, illustrates the effect of terrain and climate on tire mileage.

Tire wear, like most tire failures, is sensitive to load. Tires overloaded 10%, for example, may deliver 30% less tread mileage than tires run at standard loads.

Tires are subject to many types of irregular wear. When one part of a tread design wears more rapidly than another, that area is undergoing a greater amount of movement in contact with the road surface. This spot then undergoes progressively greater movement because it exerts less pressure against the road to resist tread movement. Fig. 5 shows two examples of irregular tread wear—rib wear and angle wear.

Practically all types of irregular wear become more aggravated as tire deflection is increased. In other words, the lower the inflation pressure or higher the load, the more likely the tire is to develop irregular wear.

*Paper, "Tire Wear And Durability," was presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 7, 1951.

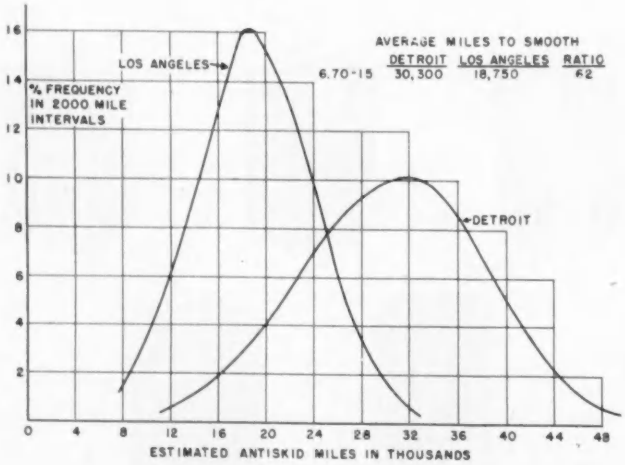


Fig. 4—Climatic and geographic differences have an effect on tread wear

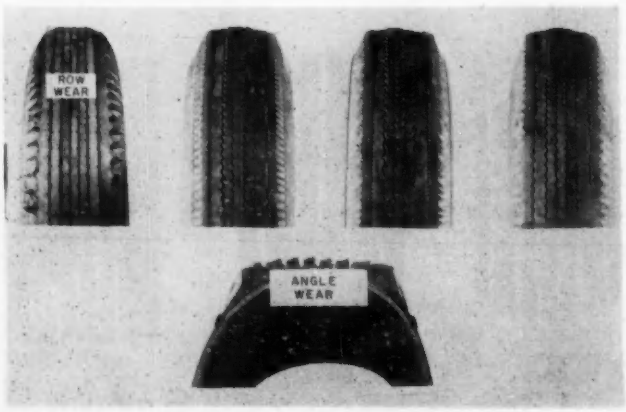


Fig. 5—Two examples of irregular tread wear

Riding Comfort

BASED ON PAPER* BY

R. D. Evans

Manager, Tire Design Research Goodyear Tire & Rubber Co.

PRESENT-DAY laboratory tests permit tire engineers to get an index of tire riding qualities before they are road tested. These tests are not considered in any way a substitute for actual road testing. The quantitative information obtained from them is valuable but only to the extent that it can be correlated with properly conducted road tests.

A relatively simple laboratory test establishes an index of the tire's enveloping power (ability of tire to accept an irregularity or unevenness of deflection without a corresponding disturbance of the normal force action between it and the rim).

Tires are deflected against a platen which is free to move parallel to the plane of rotation of the tire. The axis of rotation of the tire remains at a constant level above the platen as long as the surface is flat and the tire load kept constant. But when

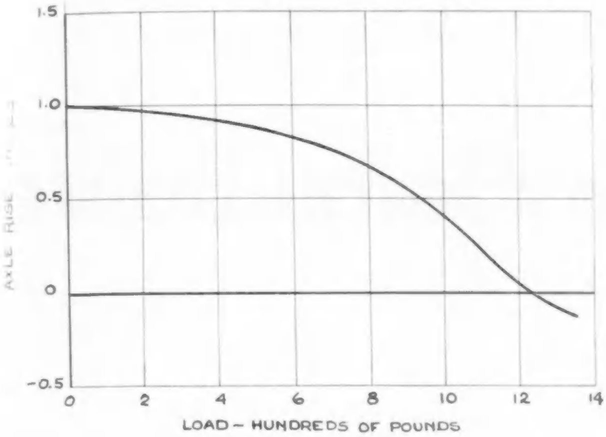


Fig. 6—Effect of load on axle rise

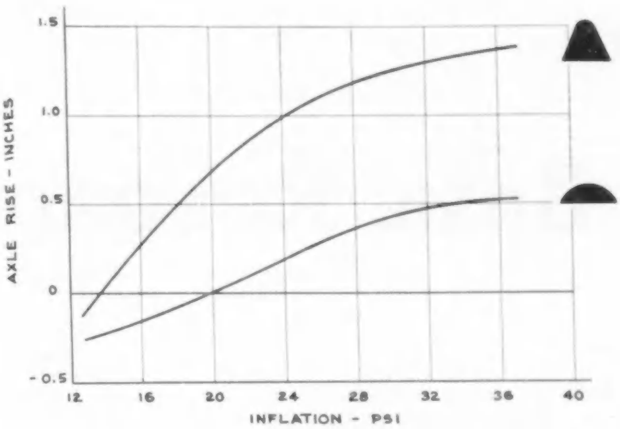


Fig. 7—Effect of inflation pressure on axle rise of a 7.60-15 tire

a cleat is placed on the platen, the axis rises as the tire rolls over it. This height at maximum is called axle-rise.

Degree of axle-rise obviously depends on the choice of obstacle. But values found by testing a variety of tires, using various inflation pressures, loads, and obstacles, are in reasonably constant ratio and good correlation with ride experience on the road.

The effect of load and inflation pressure on axle-rise is illustrated in Figs. 6 and 7. Tire cord angle is another important factor in determining degree of axle-rise, as shown in Fig. 8. (Tire cord angle is here defined as the angle between the cords and the plane of rotation measured at the tread center.)

Clearly the axle-rise technique involves only dynamic effects perpendicular to the platen or road surface. Tire suspensions are specifically designed to deal with these vertical forces and accompanying disturbances.

But when a tire rolls along under load, there are other forces acting on it—both in the lateral or axial and in the fore-and-aft or tangential directions. These forces have received much study, the former from the standpoint of cornering or steering action as factors in car control and the latter from the standpoint of drag or power consumption and of tractive and braking action. However, until very recently the perturbations of these forces caused by road roughness or irregularities received little study.

Strain gage methods now permit investigating these horizontal components throughout the range of speed in which tires make their most important contribution to riding comfort (15 to 45 mph).

Tires are mounted on a fixed axle, so placed as to deflect them—with the desired loading—against a large diameter flywheel. Strain gages on the axle register the radial and flywheel impact effects as the tire passes, at various speeds, over a half-round cleat on the flywheel.

Obviously this abnormal condition forces the tire to completely envelop the cleat, causing both tire

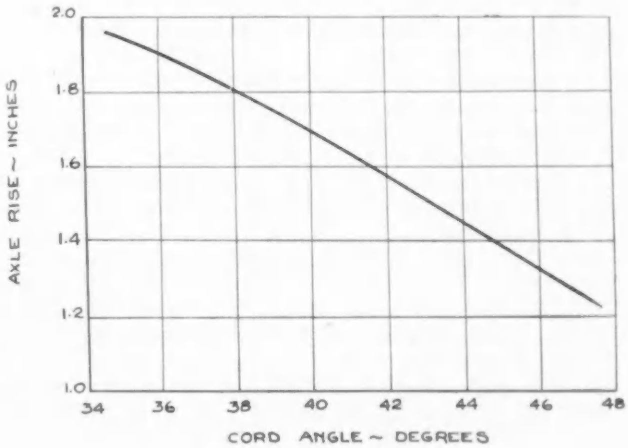


Fig. 8—Effect of tire cord on axle rise

membrane vibration and axle vibration. Test results indicate however that fore-and-aft impacts are of important magnitude, comparable to radial ones. And while suspensions permit tires to rise, partially hopping over and partially enveloping an obstacle, tangential impact is only reduced, not fully eliminated.

Meager information is available concerning the ride-affecting characteristics of the lateral impact effects due to road irregularities. Special strain gage installations permit measurement of these effects at and parallel to axle bearings. (Measured in this way they are completely segregated from any fore-and-aft impact effects.)

It is clear that these impact effects are not of negligible magnitude. And that the various types of suspension, both front and rear, have very little "spring" or impact absorption with respect to them. Insofar as they are a factor in riding comfort, tires are almost entirely the means whereby any cushioning or impact absorption is obtained.

There is a definite need for more intensive exploration of systems of horizontal forces and impact effects from the standpoint of their effect on ride. In this, the tire engineer must be joined by suspension, chassis, and highway engineers.

*Paper, "Riding Comfort," was presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 7, 1951.

Basic Research Helps Solve

PRESENT-DAY basic research methods help to solve difficult seaplane design problems. "Basic research" (defined in this case as a method used to gain an understanding of the physical laws which govern action of the body on the water) may be divided into three types:

1. Experience with full scale designs
2. Model tests
3. Analytical studies

Basic research is more than a collection of data and formulas. It is the use of this information to answer the question "Why?" For example, test of a model seaplane hull may show what will occur under a given condition. To the shortsighted, this is sufficient for the problem at hand. But, in the hands of an investigator who relates the "what" to other data and determines why, the result becomes a part of basic research.

In the beginning of seaplane development, practically all experience and design information was obtained on full size airplanes. Only demonstration of satisfactory take-off and landing was required. Now, however, thoroughly instrumented flight-test seaplanes record power, speed, trim, control position and forces, impact, and similar information under controlled piloting technique. And these data are valuable both for demonstration of satisfactory performance on the water and for furtherance of research.

Use of model tests as a guide to hull design has been accepted practice for many years. Today, techniques for model tests are developed to a high degree. Dynamically similar scale models reproduce not only exterior forces and moments on the body but also react to applied loads with dynamic motions similar to the parent design. Powered dynamic models—complete with aerodynamic surfaces—and radio-controlled free-flight models permit evaluation and study of specific seaplane designs.

Less spectacular, but more adaptable for the purpose of basic research, are techniques developed for use of small models in the towing basin. Simple and easy to build, these models are constructed to represent the portion of the design affected by the water. Simulation of aerodynamic factors is achieved through a system of springs and dashpots, which represent wing and tail effects. And simple adjustments to the mechanical portions of the apparatus permit testing a given hull-form under a wide range of aerodynamic or structural conditions. (Since aerodynamic forces are applied according to design conditions not generated by the model, there

Fig. 1—Seaplane in planing attitude

Seaplane Design Problems

BASED ON PAPER BY

John D. Pierson, Glenn L. Martin Co.

• Paper, "Application of Basic Research To Seaplane Design," was prseented at SAE National Aeronautic Meeting, New York, on April 16 ,1951.

is no complication in separating the hydrodynamic from the aerodynamic effects.)

Use of these small size models present an excellent opportunity for close observation of their performance under varied operating conditions. In addition to normal measurements made, photographic records of the water flow may be obtained from both below and above the surface. Furthermore, these easily-modified and accurately-controlled models are ideally suited to broad test programs because of low cost of construction and test.

Interpretation and general use of information obtained from full-scale flight test or model test depends upon analytical studies. Experimental methods can demonstrate the hydrodynamic phenomena and measure the lift, drag, moment, spray and stability. And empirical formulas for these quantities may be developed without any knowledge of theoretical studies. Nevertheless, use of this information is limited until the underlying reasons for the obtained phenomena are known. Analytical studies, therefore, are an essential part of basic research.

A description of several studies and their applications will illustrate how analytical studies aid in the understanding of observed phenomena and may lead to further development.

Consider the planing condition shown in Fig. 1. Many significant features, such as spray, resistance, wetted area, and center of pressure may be observed and measured either on the full-scale airplane or on a model in a towing tank. But this sort of specific information will apply only to a similar condition on an identical hull shape. Certain portions of the flow pattern are of a more general nature, and it is to these that analytical studies are applied.

For example, a section "A-A" through the hull will appear as shown in Fig. 2. This depicts the general problem of penetration of a fluid surface by a wedge. The penetration of the wedge, displacing the fluid, raises the free-water surface which curls around at the wedge surface to shoot out as spray. This is similar to the action of the seaplane V-bottom throwing out a sheet of spray as it slices through the water.

The analytical solution to this problem is based upon observed conditions. The free surface of the water, open to uniform air pressure, is a surface of constant pressure. Relative incompressibility of water requires that the amount of fluid displaced appear in the spray. Mathematically, it is necessary to assume that the water was initially at rest and acts as a perfect fluid. It is then possible to formulate the problem and obtain an analytical solution for the flow field.

The value of this solution for the flow field is in the information gained which would otherwise be unavailable. Actual surface shape and spray thick-

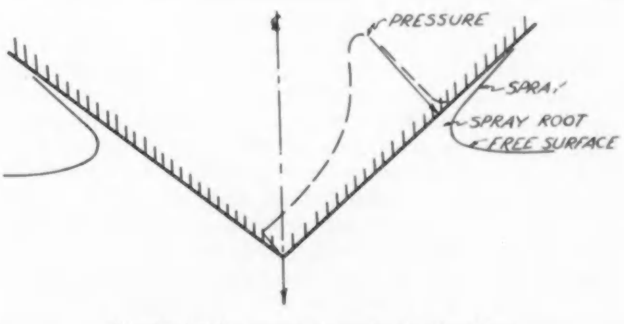


Fig. 2—Wedge penetration of a fluid surface

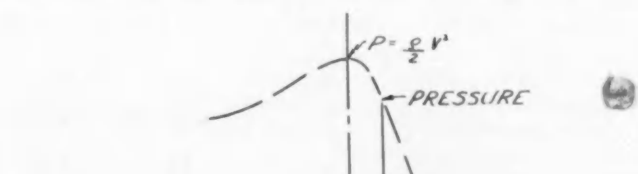


Fig. 3—Flow field in spray root

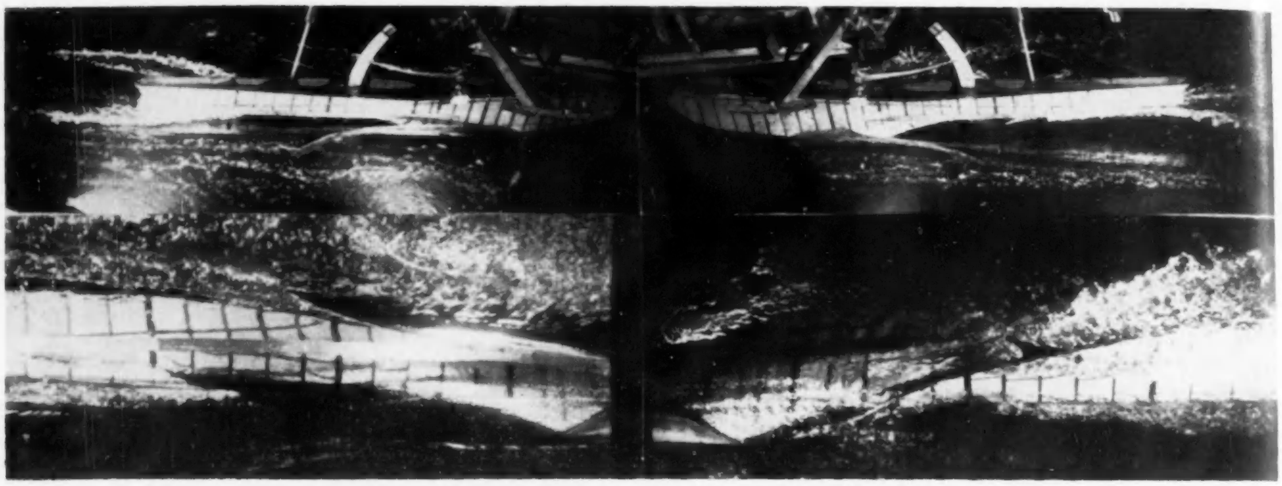


Fig. 4—Over and underwater views of flow for a yawed model

ness, given by the analytical solution, lead to a direct determination of the virtual water mass—an important item in study of stability and impact on water. The local velocity and pressure distribution across the section are also given. (Pressures on the bottom are of particular interest because of their direct effect upon structural design.) Some of these data could be obtained by direct experimental measurement, but tests would be greatly complicated by the transient nature of the flow.

Application of this solution of the two-dimensional flow in a section is extended by further analysis of the local region of the spray root. The spray root, Fig. 3, is the area where the water surface bends up toward the solid boundary, and then outward as spray. Mathematical analysis of this local area provides the relation between pressures, dimensions, and velocity in a general manner.

It shows that, for the formation of spray, there exists a sort of stagnation point of maximum pressure on the body close to the spray root. This peak pressure is the dynamic head of the fluid in the spray root with respect to the undisturbed water.

On the basis of this analysis, it is possible to relate the solution for the wedge penetration with the actual three-dimensional planing conditions. And an approximate solution for the entering portion (leading edge) of the planing surface is obtained.

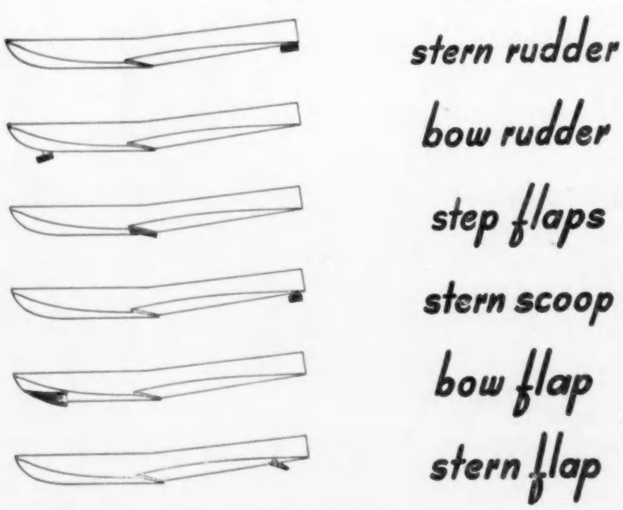


Fig. 5—Devices to aid maneuverability of seaplanes on the water

Analytical solutions for flow around planing bodies have not been extended to the point where they can eliminate model test and other empirical methods. In fact, that is not the goal of such studies. Rather the purpose is to provide a foundation for proper interpretation and use of experience gained from other designs and data obtained from model testing.

The value of basic research methods in helping to solve hydrodynamic problems is well-illustrated by the following examples.

During recent development of the long afterbody hull-form, there arose a problem in directional stability which for some time could not be solved. Models of the planing-tail and extended afterbody type encountered difficulty with directional stability on the water, while other models of similar proportions had satisfactory stability. Modifications that corrected yawing moments on one model had no effect on another. Trial and error cured the trouble in each particular case, but the overall problem was not solved.

Here was a real challenge. Could analytical methods explain this hydrodynamic behavior?

First step in this approach was to obtain a better picture of the flow around the model. Simultaneous sets of pictures were taken from positions both above and below the surface of the water. Results of this technique are shown in Fig. 4. (Since this is a yawed condition of the model, the flow is unsymmetrical, and both right and left side-views are shown.) In some areas of the underwater views, the model is indistinctly seen through the free surface, but actual wetted areas of the bottom stand out clearly.

The clue to the unstable yawing moments was at once apparent in the unsymmetrical wetting of the afterbody. The path of the wake from the forebody (in the yawed conditions) gradually deviated from the centerline of the hull, causing the afterbody to ride on the side of a longitudinal wave. This effect evidently was overcoming the stabilizing moment of the afterbody as a fin.

Magnitude of the loads on the wetted portions of the afterbody was estimated from the appearance of the spray and spray root area. (A clean-cut leading edge, with spray clearly defined, indicated full planing action . . . . irregular and ill-defined leading edge and spray indicated little planing and low pressures.)

Further study of pictures, test data, and analysis of moments so well defined and explained the problem that a satisfactory solution was easily obtained by lowering the afterbody keel.

Development of the hydroflap, an aid to maneuvering large seaplanes on the water, illustrates another successful application of basic research. The current trend toward longer hulls carried with it inability to turn and maneuver the seaplanes in restricted water. It became necessary to develop a device to provide required control. The only restriction placed on type, or location on the hull, was that it be structurally feasible.

The obvious solution was a rudder at the stern. However, it was realized the obvious answer is not always the best one. Study of the flow conditions around the hull, in the range of speeds for which turn control was needed, indicated that bow flaps, bow rudders, stern flaps, step flaps, stern scoops, and auxiliary power should also be considered. With little or no actual design information available, size for each of these configurations was estimated on the basis of the limited analytical studies available.

The different devices, shown in Fig. 5, were applied to the towing-basin model for tank tests. And the most promising ones chosen for further refinement in the towing tank and turning basin. Stern flaps, selected as the best of these configurations, did the job of turning as well as, or better than, rudders—and designing a retraction system for them was much easier.

The value of application of basic research methods to these problems is apparent. In the former case, no other approach provided a satisfactory solution to the directional instability. And, in the latter, the obvious solution—a rudder—was supplanted by an equally effective device of less structural complication.

Another important consideration is the short time taken to solve these problems. Only about two months elapsed from the date of the request for improved maneuvering to the completion of model tests and the recommendation of the hydroflap. Six months later they had been incorporated in the airplane and shown to be eminently successful.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)

PLANETARY GEARS

Continued from Page 33

for radial location and spacing. Concentricity of the three shafts with the carrier mounting spline is held within 0.002 total indicator reading. Parallelism of the shafts with the mounting spline is within 0.0006 per in.

The planet pinion thrust surfaces in the carriers are held square with the mounting splines within 0.001 and have a surface finish of 80 micro-in. maximum finish.

In general, leads on all gears are held to plus or minus, 0.0003 in width of face from the lead specified, with maximum error between teeth on any gear of 0.0006 in the width of the face.

Involutes on all gears are held to plus or minus 0.0002 variation from that desired. None of the gears are cut with true involutes. The pinions are cut full at the tips, while the ring gears and sun gears are cut full at the roots with all teeth having a slight tip relief to ease engagement.

Many steps are taken during manufacture to insure gear quality. Some of them are:

1. The metallurgical department tests sample gears from each furnace load for hardness, case depth, and microstructure.

2. Furnace atmospheres are subject to continuous gas analysis to insure proper case structure and depth.

3. The inspection department gear laboratory keeps permanent records of each heat and batch of gears. Sample gears from each batch of gears are inspected in the green for size, out-of-round, involute profile, and lead. Sample gears are then heat-treated with their own batch and reinspected. Pertinent data are recorded, such as furnace temperature, steel lot number, quench medium, quenching medium temperature, agitation, Gleason Press pressures and times.

4. Gears are rolled on hand fixtures in the green and hard, during manufacture.

5. All gears are run on speeders to sound test for nicks, runout, off lead, and so on, before assembly.

6. Front and rear units are sound tested as subassemblies, with sun gear, ring gear and carrier assemblies being selected and interchanged as required. Gears that sound quiet on the speeders often match up to produce a higher noise level than that tolerated. Upon re-assembly with other units they may be satisfactory.

The complete gearset assembly is then sound tested on a fixture simulating actual transmission operation. A quality control chart is kept of this operation so that any trend toward noisy gears can be instantly spotted and corrective measures taken. Conversely, trends toward quieter gears can also be spotted and, with the heat-treat and inspection records available, quiet gears can be produced more consistently.

8. Transmissions are continuously ridden in cars for overall performance as a further precaution in maintaining transmission quality.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Role of Boron

THE PRESENT emergency has created a critical shortage of several alloying elements vital to industrial manufacture. Cobalt, columbium, tungsten, nickel, and molybdenum are in the critical category at present, with the ever-present threat that chromium and manganese may eventually fall in the same category. Today, there is practically no cobalt, columbium, or tungsten, and less than half enough nickel and molybdenum to produce steels containing these elements for other than military applications. The alloy shortage is worse now than in World War II because: (1) we were forced to make extravagant use of the ores of the highest grade during that emergency and are now mining deposits of lower grade; (2) we are producing 30% more steel; (3) military, naval, and aircraft equipment today require richer alloys.

Because of the seriousness of the "critical alloy" problem, and the return to many of the controls of World War II, such as CMP where the demand and supply of steel and the alloys must be brought into balance, it is imperative that we take stock and plan for the future. If the present conflict in Korea should spread, the demands for alloy steels for military equipment may leave little or none for other uses. There is one ray of hope which brightens this rather dim picture, at least in so far as heat-treating steels are concerned, and that is the potentialities of the element boron for increasing the hardenability of steel. Our present knowledge of the behavior of boron in steel has been summarized in this article, based on data collected from a variety of sources, including cooperative work of the American Iron & Steel Institute and SAE. The author realizes our knowledge is not complete, that we are learning more about the behavior of boron steels every day. Thus, some of the claims or limitations presented here may not be valid a few months hence.

Although large-scale industrial use of boron in steel did not begin until the latter part of World War II, Guillet predicted in 1907 that boron steels might have industrial uses. It is also significant that Walter, in 1924, obtained a patent covering the use of boron to increase hardenability. However, the effect of boron on hardenability was not widely recognized until early in World War II, when correlation of hardenability with chemical composition became invaluable in devising alternate steels.

During the latter part of World War II, thousands of tons of boron steels were produced and used in military equipment and since 1945, there have been several large production applications of boron steels.

The Metals Handbook of the American Society for Metals concisely describes the role of boron in steel as follows: "Boron is used in steel for one purpose only—to increase the hardenability; that is, to increase the depth to which the steel will harden when quenched. Only a few thousandths of a per cent is ordinarily added." In Fig. 1, typical end-quench hardenability curves of 8645, 8645 plus boron, and 4340 illustrate the potent effect that boron exerts on hardenability. It is evident that boron can replace several hundred times its own weight of other hardening alloys, such as manganese, chromium, molybdenum, and nickel. In the example shown, 0.001% boron is contributing the same hardenability effect as 1.33% nickel plus 0.31% chromium plus 0.04% molybdenum, or a total of 1.68% of alloy. The effect of boron on hardenability decreases with increasing carbon, as shown in Fig. 2.[1] Boron is more effective in the conservation of critical alloys in the lower carbon steels; consequently, the carburizing grades of alloy steel having less than 0.30% carbon are more fertile fields than spring steels at 0.60% carbon.

Isothermal transformation (*IT*) diagrams in the region of the "nose" are helpful in understanding the behavior of boron steels during conventional heat-treatments, such as quenching, normalizing, and annealing. Fig. 3 shows 1345 plus boron plotted on the same diagram as 4140. Notice that the time for beginning of transformation at the "nose" is approximately the same (reflecting equivalent hardenability), and yet the time for completion is much shorter for the 1345 plus boron. (Completion time for 1345 plus boron is only slightly longer than for 1345 steel.) In this respect, boron as an alloying element is unique. It delays the start of transformation appreciably while delaying completion only slightly. This has a practical application in that a lower alloy steel containing boron can replace a higher alloy steel to obtain the same properties when hardened, yet the boron steel can

[1] See ASM Transactions, Vol. 40, 1948, pp. 1099–1123: "Effect of Carbon Content on Hardenability of Boron Steels," by G. D. Rahrer and C. D. Armstrong.

LEGEND	GRADE	C	Mn	Si	Ni	Cr	Mo	B
		CHEMICAL		COMPOSITION				
X——X	4340	.40	.70	.27	1.84	.81	.25	NONE
O——O	86B45	45	.81	.27	51	.50	21	0012
Δ——Δ	8645	45	.85	.29	.56	52	20	NONE

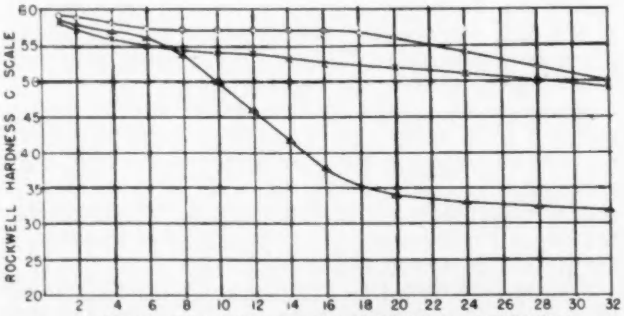


Fig. 1—End-quench hardenability—average heat—for 4340, 86B45, and 8645

Steels in Present Emergency

PAPER BY

P. R. Wray, Metallurgical Engineer, Alloy Steels, U. S. Steel Co.

• This paper was presented at the SAE National Passenger-Car, Body, and Materials Meeting, Detroit, March 7, 1951.

be annealed with a much shorter cycle. Such steels are also softer than the higher alloy steel in the as-rolled or normalized condition, provided the size is sufficiently large that air quenching does not occur.

Boron apparently has little effect on the Ae_1, Ae_3, or M_s temperatures of the base composition. Table 1 shows Ae_1 and Ae_3 temperatures determined by our research laboratory for several carburizing steels. The M_s temperatures were calculated, due to the difficulty of determining them in low carbon steels. Udy[2] has previously shown that boron has an insignificant effect on the M_s temperature.

Grain Size and Notch Toughness

Boron tends to lower the austenite coarsening temperature of a steel and, in some of the early work, this effect caused undue alarm. This can be counteracted by a judicious increase in the aluminum addition used for grain-size control.

The effect of boron on notch toughness is not clear at this date. Early work based upon comparison of the same composition with and without boron indicated that boron enhanced the notch toughness at high hardness levels (R_c 50 and above) and reduced the notch toughness at lower hardnesses. However, when a lower alloy composition containing boron is compared to a higher alloy steel, this effect of boron may be masked by the effect of other elements upon notch toughness. For example, Table 2 shows the notch toughness of 81B40 to be slightly better than 4140 when tempered to the same hardness.[3]

In any event, the notch toughness is adequate in all cases for most engineering applications.

The endurance limit and endurance ratio, as determined by laboratory and field testing, are the

[2] See **Metal Progress**, Vol. 52, August, 1947, pp. 257–264: "Boron in Steel," by M. C. Udy.

[3] Private communication from Jerome Strauss, Vanadium Corp. of America.

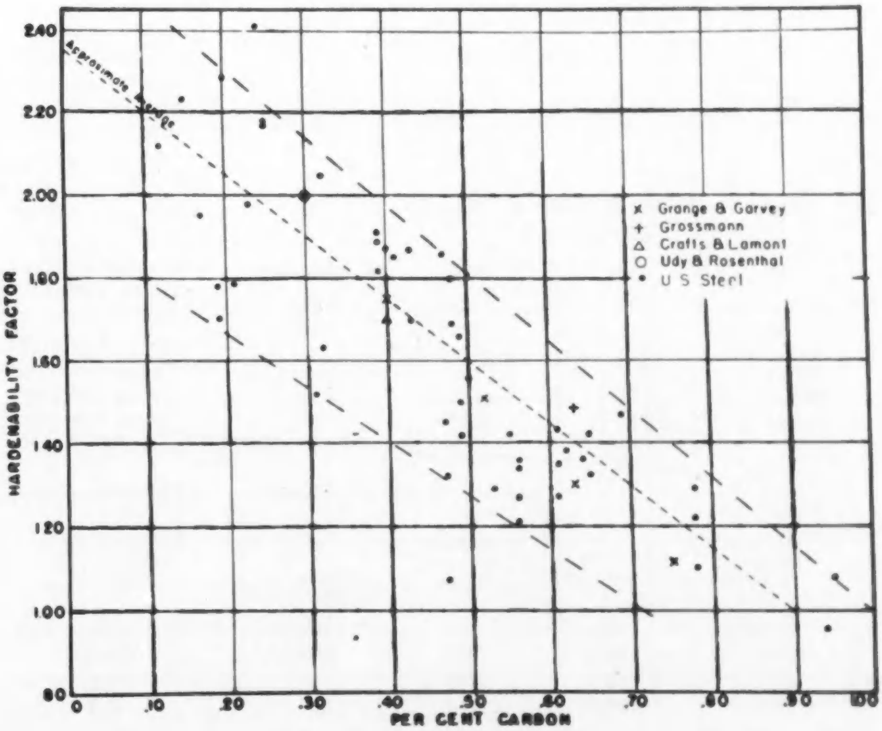


Fig. 2—Effect of carbon content on hardenability factor for boron (based on ideal critical diameters derived from 50% martensite critical hardness)

same for a given hardness as in other alloy steels heat-treated to the same hardness.[4,5]

Tempering Behavior

To the best of the writer's knowledge, boron in the amounts normally used does not increase the resistance to softening on tempering, as do other alloying elements, particularly vanadium, molybdenum, or tungsten. When boron is used to replace these elements partially or completely to obtain equivalent hardenability, it is usually necessary to use a lower tempering temperature to obtain a given hardness and strength. Robbins and Lawless[6] reported that the tempering temperature for 1045 plus boron had to be lowered 100 to 150 F to match the hardness of 9440. In the Ordnance project,[4] 150 to 200 F lower temperature was necessary with 1345 plus boron to match the hardness of 4145. Thus, although it is possible to obtain an equivalent quenched hardness with a boron steel, it is wise to run pilot tests to determine the correct tempering temperature. As shown in Table 2, the tensile strength will be the same at the same tempered hardness, even though a different tempering temperature is used.

Since boron apparently does not retard softening appreciably during the tempering treatment, it is anticipated that such steels would not be adequate replacement for higher alloy steels containing higher molybdenum, vanadium, or tungsten for high-temperature service.

Grange and coworkers[7] stated that, "when annealed to a microstructure of pearlite, or of ferrite and pearlite, such as might be encountered in the center of quenched large pieces of certain grades of moderate and low hardenability, boron apparently had an adverse effect upon tensile properties and especially upon notched-bar toughness."[7] Thus, it is essential that the hardenability of the boron steel be sufficient to obtain martensite prior to tempering so that optimum properties can be developed at the location in the part where the highest stresses are encountered.

Processing Characteristics

There has been little mention of the very desirable processing characteristics of boron steels, such as forgeability and ease of cold-heading, descaling, annealing, and machining. Robbins and Lawless of Plomb Tool Co.[6] reported the data in Table 3, based on thousands of tons of 1045 plus boron steel made into the same parts (various types of wrenches) as were formerly made from 9445 steel.

The 1045 plus boron steel had a lighter and less adherent scale, which was easier to remove than the scale on 9445 steel and required 30% less pickling.

The above performance is probably the result of the lower total alloy content of the 1045 plus boron. Other shops concur that the boron steel behaves the same as the base composition without boron.

A large manufacturer has reported the data shown in Table 4, based on hundreds of tons of 1035 plus boron used for cold-headed bolts and capscrews.[8] In this case, 1035 plus boron has replaced the 8640 formerly used.

These bolts develop the same properties when heat-treated and yet the lower alloy content (about 1¼% less) of boron steel led to real shop economies.

It was pointed out earlier that boron alloy steels should be easier to anneal than the higher alloy steels they replace, because the boron steels have about the same annealing characteristics as the base composition to which boron was added. Robbins and Lawless[6] reported that they had been able to cut their annealing time and costs in half by changing to the boron steel. They also reported improved machinability, due to obtaining a more desirable structure in the boron steel.

While some of the above examples may be extreme, it is fundamental that, although a very small quantity of boron can replace a large quantity of other alloys and develop the same properties after quenching and tempering, the lower total alloy content usually improves the hot- or cold-forming, annealing, descaling, and machinability characteristics of the parts being made.

Most of the literature on boron and the data presented so far have dealt with medium to high carbon steels of the through-hardening type. During the past few years, there has been some interesting

[4] See SAE SP-10, Aug. 2, 1946, "Report on Boron-Treated Steels (Investigation of Boron-Treated Steel—Ordnance Project—Army Research & Development No. R.A.D. 1448)." Available from SAE Special Publications Department. Price: $1 to members, $2 to nonmembers.

[5] See SP-18, January, 1948, "Boron-Treated Steels in Commercial Heats (Investigation of Boron-Treated Steel—Caterpillar Project)." Available from SAE Special Publications Department. Price: $1.50 to members, $3 to nonmembers.

[6] See **Metal Progress,** Vol. 57, January, 1950, pp. 81–89: "Use of Boron Steel in Production," by F. J. Robbins and J. J. Lawless.

[7] See ASM Transactions, Vol. 42, 1950, pp. 75–111: "Effect of Boron and Kind of Boron Addition upon Properties of Steel," by R. A. Grange, W. B. Seens, W. S. Holt, and T. M. Garvey.

[8] Private communication from G. C. Riegel, Caterpillar Tractor Co.

Table 1—Effect of Boron on Ae_1, Ae_3, and M_s Temperatures (F)

Grade	Ae_1	Ae_3	M_s (Calculated)
4317	1270	1485	740
43B17	1270	1485	740
4615	1250	1465	775
46B15	1250	1470	770
8620	1320	1530	760
86B20	1320	1505	765

Table 2—Properties of 81B40 and 4140

	Type	Draw Temperature, F	Hardness Vickers-30 Kg	Yield Point (Multiply by 1000), Psi	Tensile Strength (Multiply by 1000), Psi	Elongation in 2 In., %	Reduction of Area, %	Izod, ft-lb
(1)	81B40	800	384	176.8	181.8	7.5	44.2	35/36
(2)	4140	900	388	168.8	180.3	12.0	49.5	28
(1)	81B40	900	340	155.1	157.9	9.5	46.0	46.5/47.5
(2)	4140	1000	340	150.8	161.7	14.0	48.6	40/47

Table 3—Forging of 9445 versus 1045 plus Boron		
	9445	1045 plus Boron
Forging parts per die sinking	13,000/15,000	22,000/25,000

Note: It is estimated that the 1045 plus boron resulted in a 25% increase in die life.

Table 4—Cold-Heading and Shearing of 8640 versus 1035 plus Boron		
	8640	1035 plus Boron
Trimmer Dies, pieces per grind	9,000	22,100
Shear Dies, pieces per grind	150,000	400,000
Pointer Cutters, hr per grind	1	4
Rolled Thread Dies per Grind	150,000	200,000

research and development work on the carburizing steels. This work was undertaken to find a steel with hardenability comparable to 3310 and 9310 steels, which would minimize undesirable characteristics, such as retained austenite and undissolved carbides after carburizing and hardening, necessitating expensive treatments. We have developed a steel known by the trade name USS SuperKore A, which is essentially a 4312 plus boron and 0.03/0.07% vanadium. Fig. 4 shows the hardenability of a number of heats of SuperKore A versus 3310. SuperKore A, having about 2½% lower total alloy content, has been thoroughly tested by the Pratt & Whitney Division of United Aircraft Corp. for heavy-duty gears, shafts, and pinions in their large aircooled engines, and is approved for aircraft use under AMS Specification 6266. Pratt & Whitney reported improved carburizing characteristics—much less retained austenite and undissolved carbides on direct quenching.

Fig. 5 compares the carbon distribution in the case of 3310 with that of 4317 plus boron (SuperKore AA) when carburized under the same conditions (gas carburized 17 hr at 1700 F). Fig. 6 shows the hardness distribution of the case following direct quenching. Note improved hardness near the surface of the 43B17 (less retained austenite). The Mack Mfg. Co. has had similar success with this steel and reports that transmission countershafts for heavy truck transmissions made from it have been in service for five years without difficulty.

We have extended this development to steels of lower alloy contents, such as SuperKore B (4615 plus boron) and SuperKore C (8615 plus boron), with results comparable to those reported above.

Our work on these carburizing steels over the past four years has shown that lower alloy steels containing boron will have the same core properties as the higher alloy steel they match in hardenability, and at the same time the boron steels are easier to forge, anneal, machine, and to heat-treat after carburizing because of their lower total alloy content.

We have encountered two problems associated with boron in the carburizing steels.

The first problem is that of the hardenability of the case. It was shown earlier that the hardenability effect of boron decreases with increasing car-

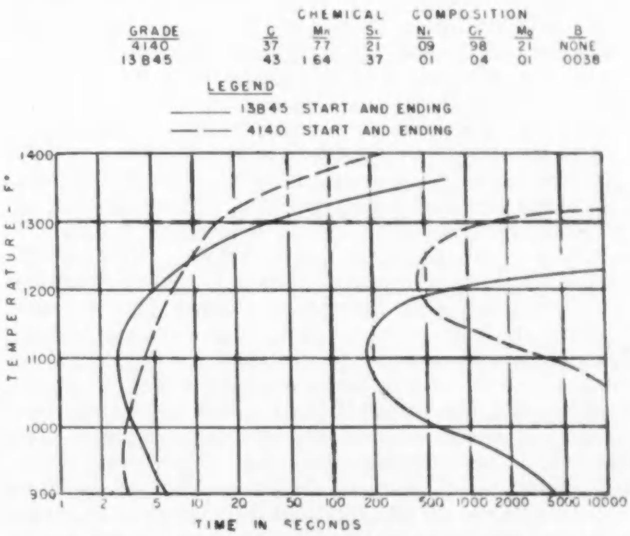


Fig. 3—Isothermal transformation in pearlite region—4140 and 13B45

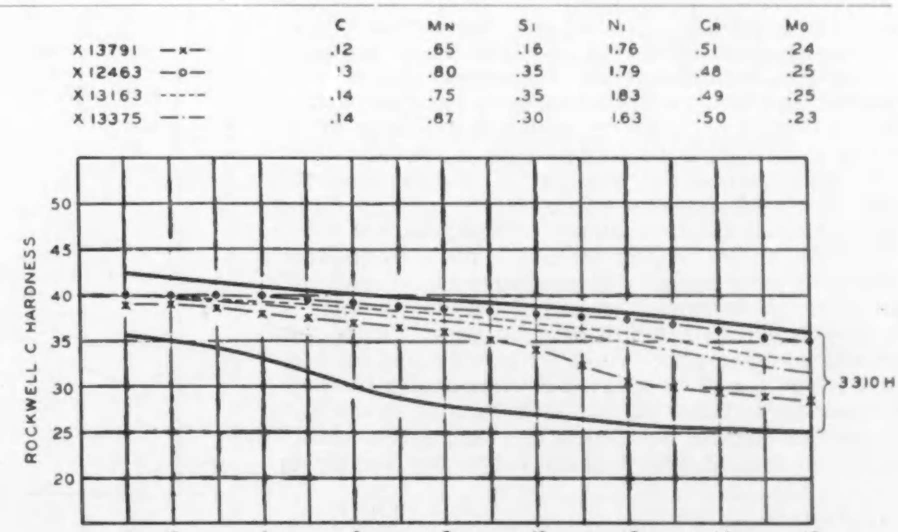


Fig. 4 — End - quench hardenability data — Superkore A

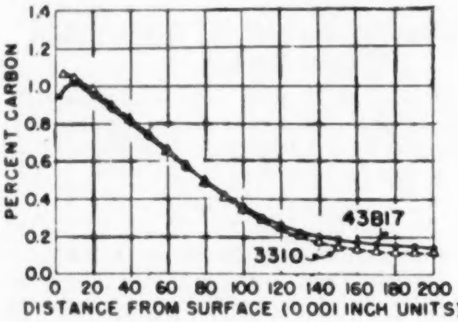


Fig. 5—Carbon distribution in 3310 and 43B17

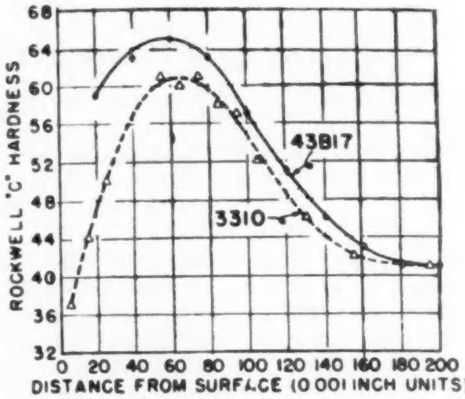


Fig. 6—Hardness gradients in 3310 and 43B17

bon content. Fig. 7 shows this graphically in a high-manganese carburizing steel (1321) with and without boron. This means that, although the core hardenability of the 1321-plus-boron steel is similar to a higher alloy steel (in this case greater than 3316), the case from 1% carbon and higher has the hardenability of 1321, and might induce soft spots in heavy sections or in smaller sections where fixture quenching is employed to control distortion. Whether this will be a serious shortcoming can only be determined on production parts. One method for minimizing this behavior is to limit the carbon in the case to a predetermined maximum. Fig. 8 compares the hardenability of 1321 and 1321 plus boron at 1.20% carbon, while Fig. 9 compares the same steels at 0.80% carbon. (Recent work indicates that, in some steels, a limit of 0.90% will suffice.) The possible reward from limiting the maximum carbon content of case is quite promising.

Concerning the second problem, Grange and Garvey first reported in 1946[9] that heating to high temperatures sometimes resulted in a partial or complete loss of the hardenability effect of boron. Grange has also found this apparent loss in hardenability in boron carburizing steels after long-time heating at carburizing temperatures followed by direct quenching. Fig. 10 shows a series of hardenability curves of 8620 containing boron. Samples were pseudo carburized (heated in vacuum) for 17 hr at the temperatures indicated and quenched. Notice that the higher the temperature, the lower is the hardenability. In Fig. 11, the curve for the sample pseudocarburized at 1750 F is replotted along with one obtained by the normal treatment of 20 min at 1700 F, followed by quenching, as well as a third curve obtained by pseudocarburizing for 17 hr at 1750 F, slow cooling to 1550 F (equalizing at 1550 F), followed by quenching. Notice that the loss in hardenability encountered in the direct quenching from the carburizing temperature is recovered by slow cooling to 1550 F prior to quenching.[10] It is anticipated that production results will confirm the beneficial effects of this treatment; in fact, this treatment will also be beneficial to the control of distortion. Another sample was pseudocarburized for 17 hr at 1750 F, slow cooled to room temperature, reheated to 1550 F, and quenched. Since this sample developed the full hardenability of the 20-min-at-1700 F cycle, it was not plotted in Fig. 11. The mechanism of this phenomenon of hardenability changes is still conjectural.

New Boron Constructional Alloy Steels

Because of the necessity for conserving the critical alloying elements, nickel, chromium, and molybdenum, the American Iron & Steel Institute, on Feb. 12, 1951, announced two new series of steels designed to accomplish this purpose. These steels known as 80Bxx and 81Bxx (Table 5) are low nickel, chromium, molybdenum compositions containing boron, in which the boron has replaced about half of the critical alloy content of the 8600–8700 steels which were the basic National Emergency steels of World War II that have since taken their place in our mass-production industries.

As can be seen from Figs. 12, 13, and 14, the 80Bxx steels will match the hardenability of the 86xx–87xx and the 81Bxx will match the 41xx types and, consequently, should be able to replace 70 to 80% of the present constructional alloy steels on an equivalent hardenability basis. It is still too early to state

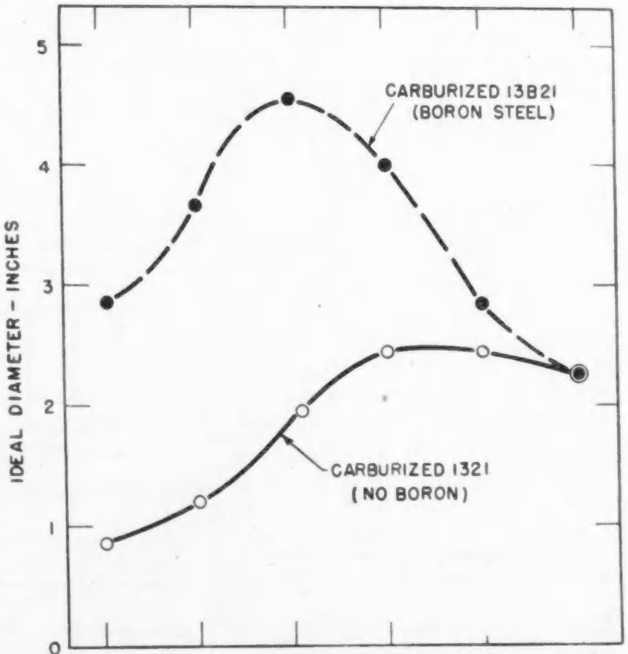


Fig. 7—Hardenability effect with increasing carbon content for 1321 with and without boron

[9] See ASM Transactions, Vol. 37, 1946, pp. 136–191: "Factors Affecting Hardenability of Boron-Treated Steels," by R. A. Grange and T. M. Garvey.

[10] Patent applied for.

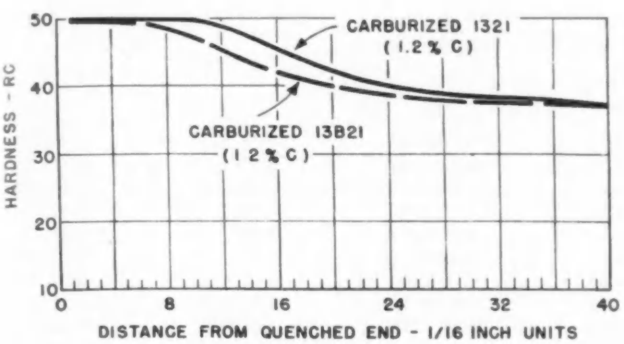


Fig. 8—End-quench hardenability curves for 1321 with and without boron at 1.2% carbon

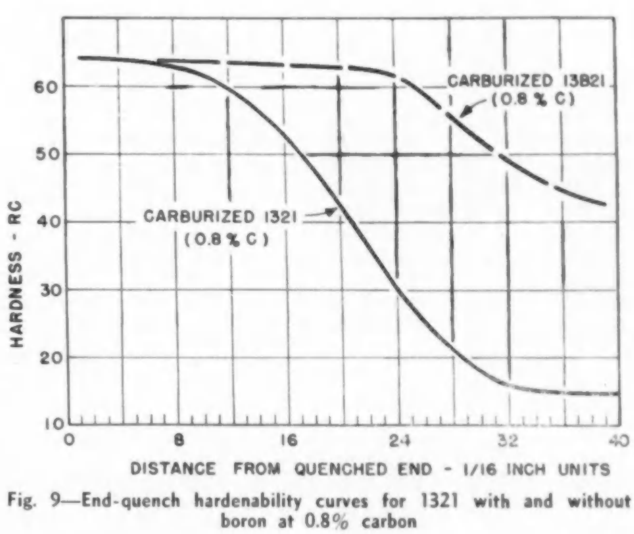


Fig. 9—End-quench hardenability curves for 1321 with and without boron at 0.8% carbon

whether the composition of these steels will have to be altered slightly, based upon production experience, since only a handful of production heats has been made. So far, the hardenability of the production heats seems to be exceeding the limits predicted from laboratory data (see Figs. 12 and 14).

In addition to the 80Bxx and 81Bxx series, three additional boron steel types are showing promise at this early date. These are the 94B17 and 94B20 for carburized parts formerly made of 4620, the 43B17 as a replacement for 4820 in carburized parts of heavy-duty trucks, and 86B45 as a possible replacement for 4340.

The Society of Automotive Engineers has established Division VIII of its Iron & Steel Technical Committee to collect and disseminate the experience gained in the production, fabrication, testing, and use of these new steels. It is anticipated that from this committee will come a vast amount of data to aid in the campaign to stretch our available supplies of alloys to the utmost.

Summary

For the majority of applications for the constructional alloy steels, boron can probably replace a sizable quantity of nickel, chromium, molybdenum, and other critical alloys where their presence is necessary only for adequate hardenability. The advantages in replacing other alloying elements with boron, aside from alloy conservation, are: (1) the improved hot- and cold-working, (2) shorter annealing cycle, and (3) improved machinability, all of which should result in economies. In replacing higher alloy contents in carburizing steels, boron contributes to simplified treatments by shortening the time cycle for annealing and minimizing retained austenite and undissolved carbides in the carburized case.

Boron steels require more care in their selection and treatment than do the conventional alloy steels, because of the following factors:

1. Hardenability must be adequate, so that a tempered martensitic structure is obtained at the location where the highest stresses are encountered. If other structures are obtained in heat-treatment, mechanical properties, particularly toughness, may be impaired to an even greater extent than in conventional alloy steels.
2. Boron exerts a pronounced effect on the hardening properties, but little or no effect in retarding softening at elevated temperatures. This usually necessitates a lowering of the tempering temperature to attain a desired hardness or strength.
3. Boron cannot perform the same function as does molybdenum, vanadium, or tungsten of contributing strength at elevated temperatures and, consequently, any attempt to replace steels high in these elements with boron steels for high-tempera-

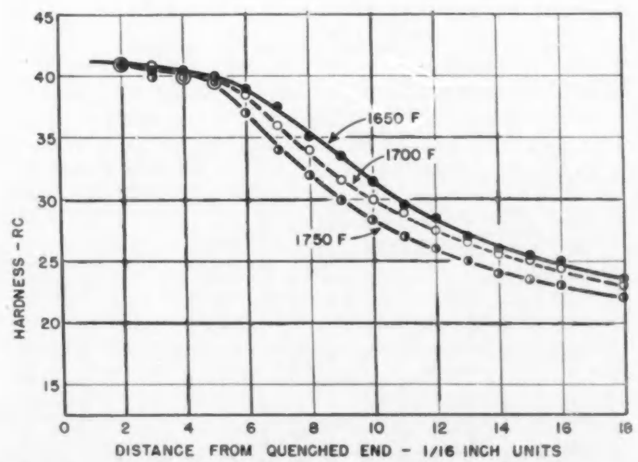


Fig. 10—Effect of pseudocarburizing for 17 hr at each indicated temperature upon hardenability of 86B20 steel

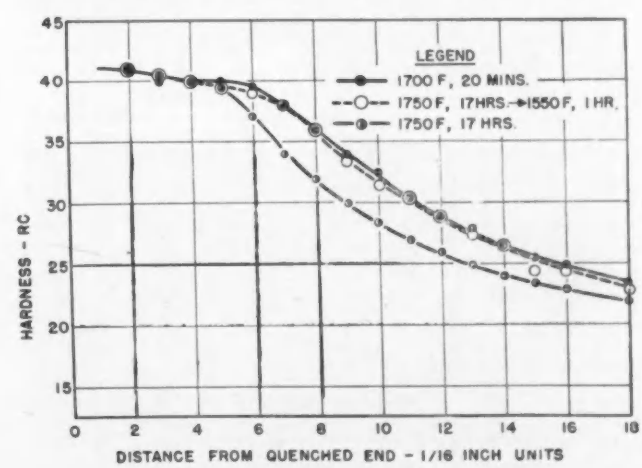


Fig. 11—End-quench hardenability curves for 86B20
C—0.18, Mn—0.83, Ni—0.49, Cr—0.49, Mo—0.19, B—0.0013

Table 5—Chemical Composition Limits (%)

80Bxx

Grade	C	Mn	Si	Ni	Cr	Mo
80B20	0.17/0.23	0.45/0.70	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B25	0.21/0.28	0.50/0.75	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B30	0.27/0.34	0.55/0.80	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B35	0.32/0.39	0.65/0.95	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B40	0.37/0.45	0.70/1.00	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B45	0.42/0.50	0.70/1.00	0.20/0.35	0.20/0.40	0.15/0.35	0.08/0.15
80B50	0.47/0.55	0.70/1.00	0.20/0.35	0.20/0.40	0.25/0.50	0.08/0.15
80B55	0.50/0.60	0.70/1.00	0.20/0.35	0.20/0.40	0.30/0.55	0.08/0.15
80B60	0.55/0.65	0.70/1.00	0.20/0.35	0.20/0.40	0.30/0.55	0.08/0.15

Note: These steels can be expected to have 0.0005% minimum boron content.

81Bxx

Grade	C	Mn	Si	Ni	Cr	Mo
81B35	0.32/0.39	0.70/1.00	0.20/0.35	0.20/0.40	0.30/0.55	0.08/0.15
81B40	0.37/0.45	0.70/1.00	0.20/0.35	0.20/0.40	0.30/0.55	0.08/0.15
81B45	0.42/0.50	0.70/1.00	0.20/0.35	0.20/0.40	0.30/0.55	0.08/0.15
81B50	0.47/0.55	0.75/1.05	0.20/0.35	0.20/0.40	0.35/0.60	0.08/0.15

Note: These steels can be expected to have 0.0005% minimum boron content.

ture applications is not considered practical.

4. Because of a decreasing hardenability effect of boron with increasing carbon content, the hardenability of the case of a carburized part may be insufficient. Some improvement can be effected by limiting the maximum carbon in the case to about 0.90% carbon.

5. Carburizing, followed by direct quenching, may decrease the hardenability of the core. Either delayed quenching (that is, slow cooling to about 1550 F prior to quenching) or double treatment seems to be an effective remedy.

6. Several new series of boron alloy steels have been developed to conserve our critically short alloys. By concentrated attention to details, it is felt that these steels will have fairly wide application.

The writer is indebted to his associates on the Technical Committee of Alloy Steel Bars of the American Iron & Steel Institute and the Iron & Steel Technical Committee of the Society of Automotive Engineers, wherein much of this work is being planned and developed, and to R. A. Grange and J. F. Boyce of the United States Steel Co. Research Laboratory for their many valuable contributions.

CHEMICAL COMPOSITION

		C	Mn	Si	Ni	Cr	Mo	B
8620	RANGE	.18/.23	.70/.90	.20/.30	.40/.70	.40/.60	.15/.25	—
80B20	LOW EXPER HEAT	.19	.50	.25	.25	.19	.12	.0007
80B20	HIGH EXPER. HEAT	.21	.60	.31	.41	.26	.15	.0009
80B20	PRODUCTION HEAT	.19	.65	.31	.33	.23	.14	.0012

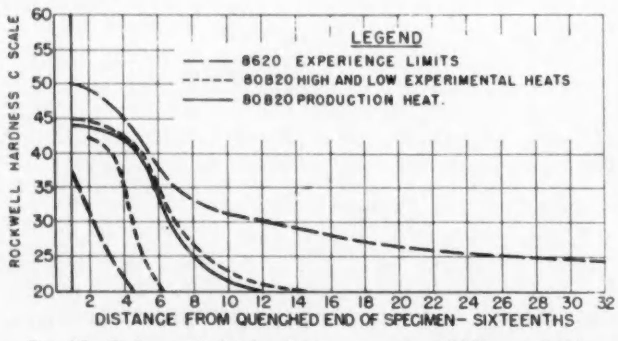


Fig. 12—End-quench hardenability curves for 80B20 and 8620

CHEMICAL COMPOSITION

		C	Mn	Si	Ni	Cr	Mo	B
8640	RANGE	.38/.43	.75/1.00	.20/.35	.40/.70	.40/.60	.15/.25	—
80B40	LOW EXPER. HEAT	.39	.62	.22	.26	.14	.12	.0019
80B40	HIGH EXPER. HEAT	.42	.90	.40	.38	.31	.12	.0020

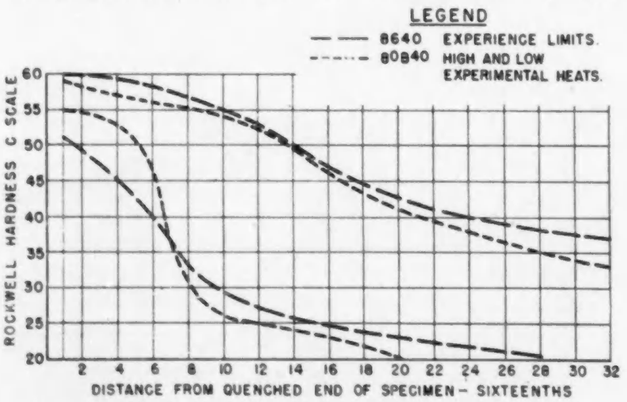


Fig. 13—End-quench hardenability curves for 80B40 and 8640

CHEMICAL COMPOSITION

		C	Mn	Si	Ni	Cr	Mo	B
4140	RANGE	.38/.43	.75/1.00	.20/.35	—	.80/1.10	.15/.25	—
81B40	LOW EXPER. HEAT	.38	.77	.28	.21	.33	.09	.0022
81B40	HIGH EXPER. HEAT	.43	1.12	.43	.39	.53	.16	.0025
81B40	PRODUCTION HEAT	.40	.85	.27	.33	.48	.13	.0011

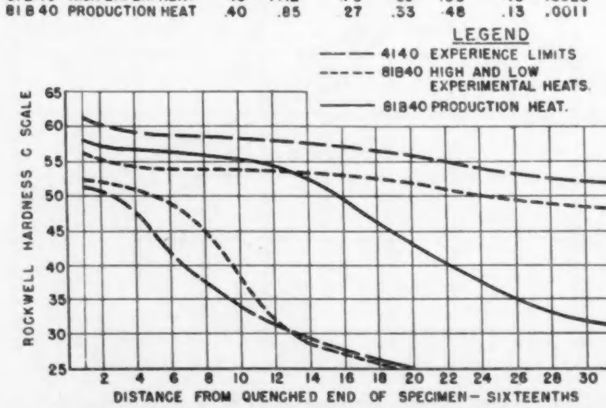


Fig. 14—End-quench hardenability curves for 81B40 and 4140

The Studebaker V-8 Engine

EXCERPTS FROM PAPER* BY

E. J. Hardig, T. A. Scherger, and S. W. Sparrow

The Studebaker Corp.

* Paper, "Studebaker V-8 Engine," was presented at SAE Summer Meeting, French Lick, June 7, 1951.

INTRODUCTION of the Studebaker V-8 engine was prompted by a desire to benefit humanity in general and Studebaker stockholders in particular. Specifically the aim was to increase sales and profits by replacing a 6-cyl car with an 8 which would cost less and yet have equal or better performance. To obtain lower cost we relied upon a chain reaction—a reduction in the length of the engine to make possible a reduction in the length of the car which, in turn, would make possible a reduction in weight.

Low cost presupposes a design which permits taking advantage of the most modern methods of manufacture. And to justify the expense of high production machinery there must be assurance that drastic changes in design will not be required in the immediate future. In a long look forward we seemed to see what other observers have reported—the possibility of higher compression ratios, and therefore smaller combustion chambers and higher cylinder pressures. Space requirements had already dictated that the engine be of the V-type, structually suited for high cylinder pressures. The threat of small combustion chambers led us, somewhat reluctantly, to overhead valves.

We faced the decision on piston displacement with conflicting desires. Naturally we coveted the comfort that comes from extra cubic inches of displacement as insurance against failure of a new engine to deliver expected power and torque. At the same time we knew that (1) big engines cost more than little ones, (2, friction increases with piston displacement, and (3) engine friction has a significant influence upon mpg.

Eventually the conflict of desires was resolved by selection of a piston displacement approximately 5% less than that of the 6-cyl engine to be replaced. Later when the car was found to weigh about 6% less than its predecessor, we felt confident of meeting our goal of equal performance without sacrifice in fuel economy. Actually we expected superior performance over most of the speed range, as the 6-cyl engine had suffered from those afflictions prevalent in engines which have been in production a long time. (Typical afflictions are enlargement of the bore and elongation of the stroke without adequate compensating corrections in such vital elements of the breathing apparatus as valves and ports.)

The bore of 3-3/8 in. and stroke of 3-1/4 in. selected gave a stroke-bore ratio of slightly less than 1.

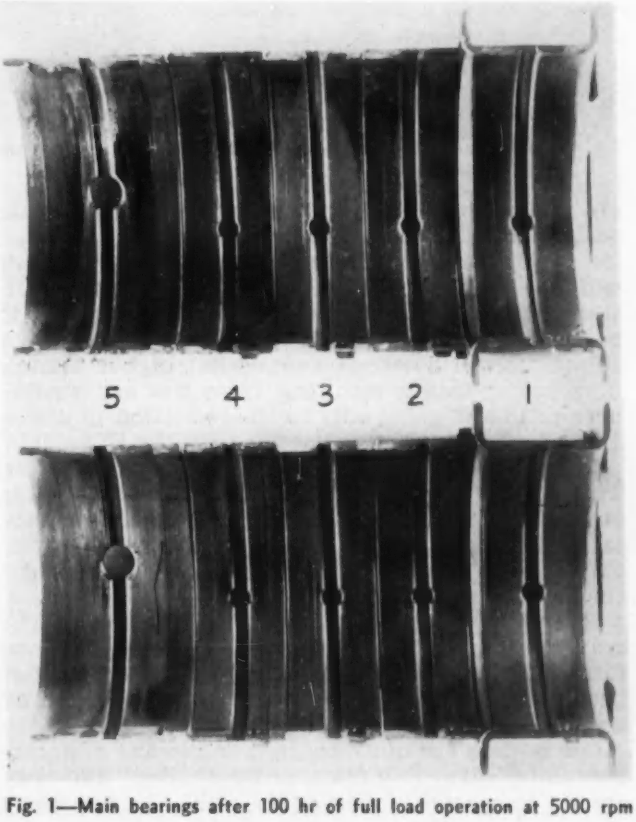


Fig. 1—Main bearings after 100 hr of full load operation at 5000 rpm

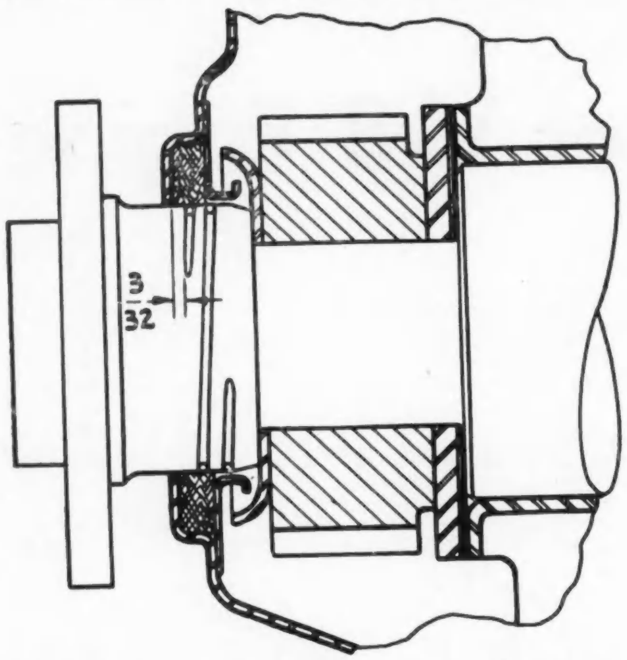


Fig. 2—Return groove of oil seal at front end of crankshaft should not project beyond front of felt washer

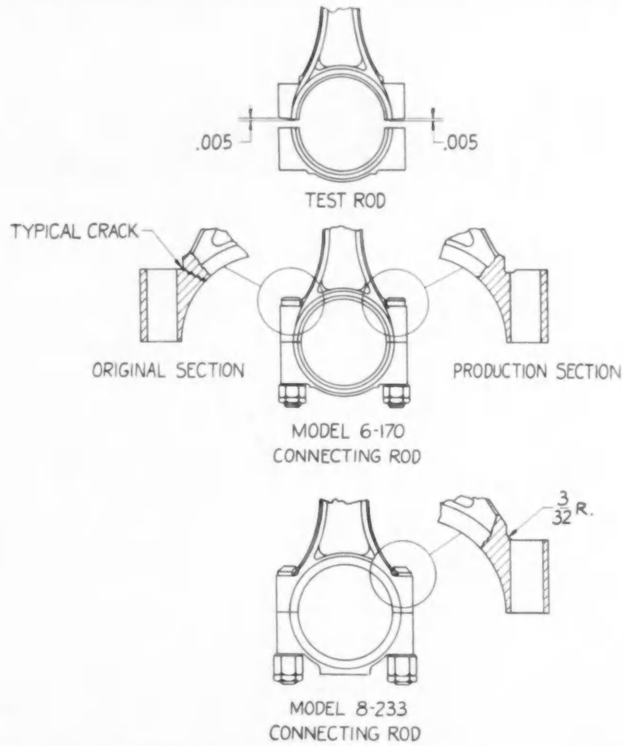


Fig. 4—Fillets are important in preventing connecting rod failures

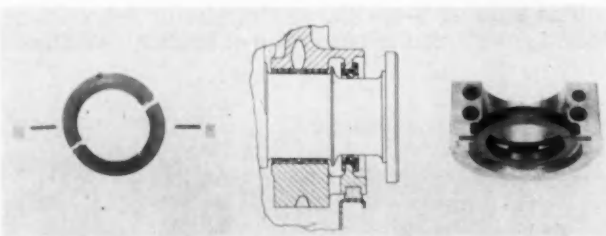


Fig. 3—To prevent leakage at the rear of the crankshaft, the sides and face of the bearing-cap, as well as the shaft, must be sealed

(In general, decreasing the stroke-bore ratio tends to increase the length of an engine and decrease its height and, in the case of a V-8 engine, its width.) Once the ratio best suited to a given installation has been decided upon, it is customary to point to its virtues and to forget its shortcomings. Hence we will ignore the somewhat higher taxable horsepower rating resulting from the low stroke-bore ratio and point only to the reduction in piston and ring friction.

Main bearings of the engine are micro-babbitt, with the thrust being taken by the flanged bearing at the front. Fig. 1 shows bearings which were subjected to 100 hr of full load operation at 5000 rpm. From the appearance of these bearings, it is evident that loads are not excessive.

The main journals of the crankshaft overlap the crankpins by 5/8 in. Although deflections due to torsional vibration are not excessive, it was felt that the added contribution to smoothness furnished by a vibration damper justified its use.

Car owners are quite content to discard a crankcase full of oil after a few thousand miles. But they are apt to become violent at the sight of a few drops trickling from either end of the crankshaft. Sealing of the shaft therefore assumes considerable importance. At the front, Fig. 2, the trick is accomplished with an oil slinger, a felt washer, and a return groove. Since the groove pumps dirt with as much enthusiasm as it does oil, it should not extend to the front edge of the felt. At the rear, Fig. 3, the barriers to escape include an oil slinger, a lip-type neoprene seal, cork-filler blocks at the sides of the bearing cap, and strips of neoprene spaghetti across the face of the cap.

Connecting-rod bearings are also micro-babbitt. These deviate slightly from a true circle with the diameter along the centerline of the rod approximately 0.001 in. less than the maximum diameter. This permits operating with a slightly lower bearing clearance, desirable from the standpoint of noise.

The big end of the connecting rod is shown in Fig. 4. Attention is directed to the 3/32 in. radius at the flat which prevents the bolt from turning.

Everyone approves of fillets but there sometimes is a question as to whether or not they are necessary. In our case, past experience answered that question . . . . experience with another engine in which connecting rod failures were very rare—but not rare enough.

Failures which occurred were in the location indicated in the upper left of Fig. 4. What made the situation particularly exasperating was the fact that, while a rod might fail in dynamometer tests under known conditions of operation, yet continued operation under the same or more severe conditions would not produce further failures.

Naturally the rods that failed were submitted to

the laboratory for metallurgical examination. This is a very desirable procedure since it provides a few hours for meditation between the time when the failure occurs and the time when the report comes back—stating that the broken part is metallurgically perfect.) During one such period of meditation, it was decided to exaggerate the various faults which might occur in a rod in an effort to reproduce this type of failure.

Rods were subjected to various indignities but consistent failures resulted only from a lack of flatness of the type indicated at the top of Fig. 4. It should be emphasized that, not even in nightmares, had we ever seen production rods out-of-flat to the extent of the rods used in these tests. Also it must be admitted that final machining of the hole in the big end relieves stresses, and therefore the mating surfaces of bearing and cap may be slightly out-of-flat.

More important than identifying the disease, these experiments furnished a means for testing the effectiveness of the cure. The cure took the form shown at the upper right of Fig. 4. Effectiveness was demonstrated by the fact that with this fillet we were able to operate rods with faces 0.005 out-of-flat for 100 hr at 5000 rpm without failure, as compared to failures at the end of 7, 16, and 30 hr with the original construction. Still more encouraging has been the complete absence of service failures with this construction.

There are good engines which have (1) piston pins that float, (2) piston pins anchored in the pistons, and (3) piston pins anchored in the rods. Once upon a time Studebaker built an engine which had a floating piston pin and a noise. When the pin was clamped in the rod, the noise disappeared. And since the noise wasn't really needed, the latter construction seemed preferable and has been used in subsquent engines. In addition to our veneration for the past, we believe this construction has at least one argument in its favor. The design of many connecting rods is such that they deflect rather readily in a plane perpendicular to the plane of rotation. This being the case, it is highly desirable that any tendency of the rod to lean to one side or the other should be discouraged. As shown in Fig. 5, for a given clearance between pin and bearing, the greater the distance the bearing is from the centerline of the rod the smaller will be the angle at which the rod is permitted to lean.

Pistons, Fig. 6, are of the cam ground, oval type with the diameter across the thrust face being 0.007 in. greater than the diameter perpendicular to it. And the diameter at the top of the thrust face is approximately 0.001 in. less than the diameter at the bottom of the skirt. The specified "feeler-pull" gives an actual interference fit of between 0.001 in. and 0.002 in. at the bottom of the skirt. This type of piston, which has been used in previous models, has the accommodating characteristic of fitting tight at light loads, tighter at heavier loads, yet not too tight at any load.

The pistons have two compression rings of the inside bevel type, 5/64 in. wide. An inner ring is used in conjunction with the oil ring, which is 3/16 in. wide. There was a time when inner rings were seldom admitted to the polite society of new engines and were forced to associate with derelicts which had developed an unquenchable thirst for oil as they tottered toward oblivion. Today inner rings are somewhat more respected—at any rate we like them. They make it possible to obtain high unit pressures without resorting to rails with tapered sections which permit contact surface area to increase with wear.

In working out combustion-chamber contours, knowledge of the various theories concerning detonation, preignition, and combustion roughness is highly desirable. Such knowledge permits the engineer to talk impressively of flame speed, turbu-

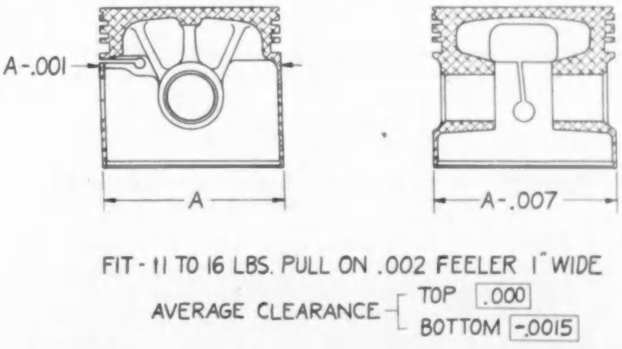


Fig. 6—Pistons are oval and slightly tapered, being larger at the bottom of the skirt than at the top

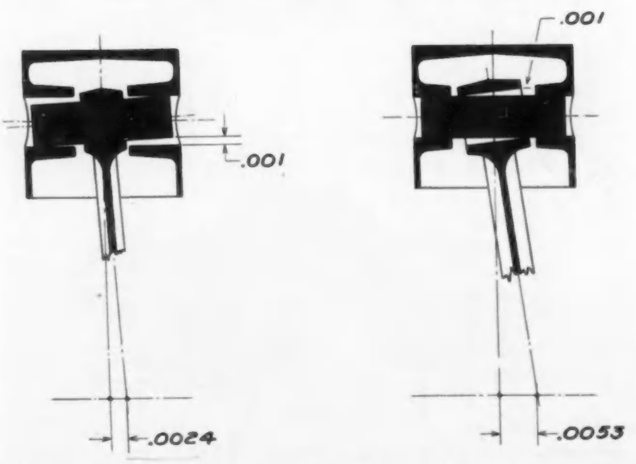


Fig. 5—For a given clearance, a rod can tip less with the bearing in the piston than with the bearing in the rod

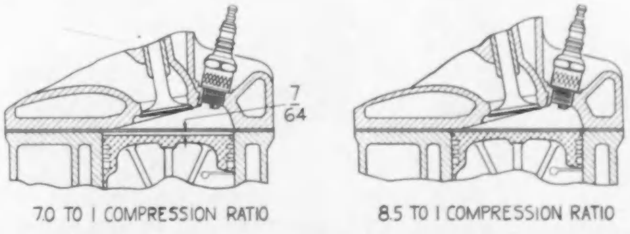


Fig. 7—Increase in compression ratio can be obtained by increasing the thickness of the piston head

lence, and quench areas while he follows the usual cut-and-try methods in developing a combustion-chamber shape that will be satisfactory. The particular shape arrived at in this engine is indicated in Fig. 7. The top of the piston is approximately 7/64 in. below the top of the block, and it is possible to increase the compression ratio from 7.0 to 8.5 merely by increasing the thickness of the piston head.

Fig. 8 gives a detailed picture of the valve train. There are two unusual items—the self-locking adjusting screw and the wire spring, which makes the lifter follow the cam after the valve reaches its seat. (Both have been used in previous L-head engines.) Perhaps a third item should be classified as unusual, namely, the absence of hydraulic lifters. This omission is due, not to a lack of appreciation of the merits of such lifters, but rather to a lack of conviction as to their necessity.

Due to the brevity of human existence, no attempt will be made to enumerate all the mistakes made or all the difficulties encountered in working out the valve train. It seems desirable however to submit a few samples.

One of the first mistakes was an attempt to use the valve spring shown at the right in Fig. 9. This spring surged badly within the operating range of the engine causing noise, which was bad, and valve failures, which were worse. Adoption of the production spring raised the speed at which objectionable surge was encountered from 3600 rpm to 5100 rpm. And tendency of the spring to surge was further discouraged by a change in cam contour. Valve spring dampers were released as an added precaution against trouble from this source.

The next item we prefer to class as a mystery rather than a mistake. The first experimental engines were built with untreated valve lifters and with camshafts having the same surface treatment as had proved satisfactory in previous models. This was acceptable to the experimental camshafts but shafts built over production tools promptly dug holes in valve lifter faces. The trouble was corrected by transferring the surface treatment from the camshaft to the faces of the valve lifters. We have accepted the solution to the problem but we haven't explained it.

Each cylinder is fed by an independent passage leading from the center section of the manifold. The floor of this center section receives heat from

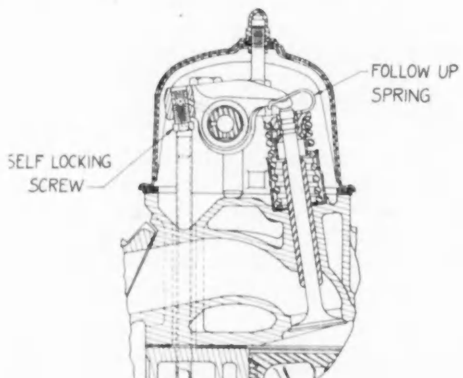


Fig. 8—Unusual features of the valve train include a self-locking adjusting screw and a follow-up spring

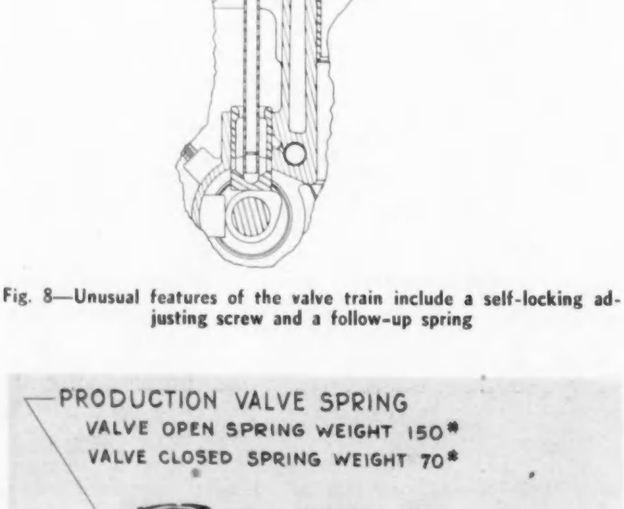


Fig. 9—Violent surge encountered with the original valve spring was eliminated by using the production valve spring

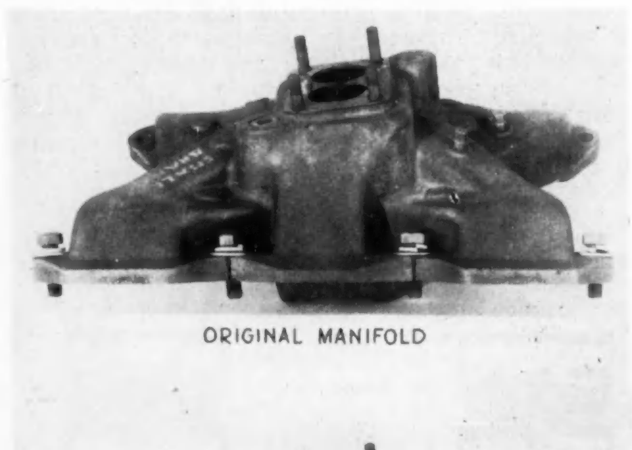


Fig. 10—Claw type clamps and long capscrews prevented different expansion of manifold branches, thus stopping leakage

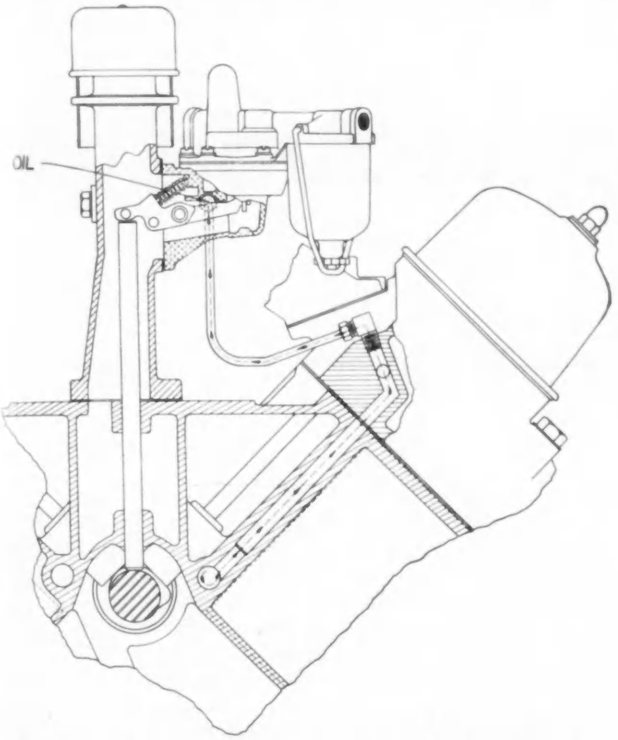


Fig. 11—Fuel pump rocker arm assembly is lubricated by a direct connection to the main oil line

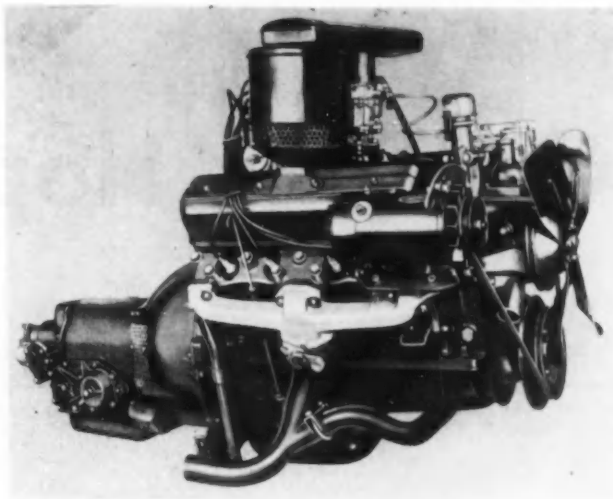


Fig. 12—Right side of engine

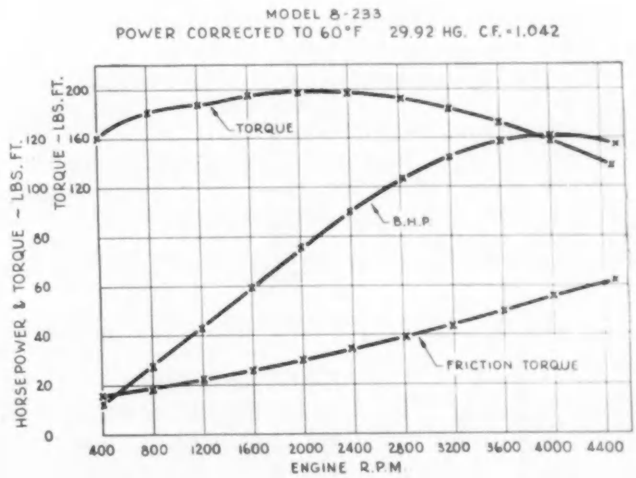


Fig. 13—Horsepower and torque, without accessories

exhaust gas passing through a branch of the manifold which connects the exhaust passages in the two cylinder heads. Naturally the branch that carries exhaust gases tends to expand more than the intake branches. And, with the manifold bolts loose, it was found the face of the exhaust flange (under some conditions) would project 0.011 in. beyond the faces of the intake flanges. Obviously it was necessary to hold these faces in line to prevent leakage. (The manifold had sufficient flexibility to permit this without cracking.) This was accomplished by changing from the original method of clamping to the claw type clamps and longer bolts shown in Fig. 10.

The carburetor is of the conventional duplex type. A certain amount of early production agony was experienced from the combination of a choke, which did not respond as the cold room had predicted, and a faulty linkage, which in some cases did not open the choke at full throttle. Fortunately these faults appeared quite promptly and service corrections were made.

There is nothing unusual in the lubrication system with the possible exception of the positive lubrication of the fuel pump rocker arm assembly, as indicated in Fig. 11. This seemed rather desirable after a few experiences with fuel pumps that failed to operate following a long series of cold room tests.

Crankcase ventilation is conventional with air entering the oil filler tube and being discharged from the trailer tube attached to the valve lifter chamber cover. As originally designed, the behavior of the system at times was a bit unconventional—oil came out where the air was supposed to come in. This resulted from too slow an equalization of pressure between the crankcase and lifter chamber and by a suction created at the entrance to the oil filler tube by the fan blast. The remedy was a lip on the filler cap and a larger hole between the crankcase and valve lifter chamber.

Now when all these things and many others like unto them had been accomplished there was constructed an engine, Fig. 12. And in this engine the pistons did go up and down and did develop pressures which were both mean and effective. And in this engine the crankshaft did go round and round and from it there came forth both power and torque, Fig. 13. And in due time there were other engines like unto this in every particular, and these engines were installed in vehicles which did move forward and backward exactly as had been planned from the beginning. And in the performance of these vehicles the owners thereof did find pleasure and satisfatcion—we hope.

(Paper on which this abridgement is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Oil Tank Hoppers Aid Low

EXCERPTS FROM PAPER BY

Saul Barron, Powerplant Laboratory, Air Materiel Command

• Paper "Low Temperature Lubrication of Aircraft Engines" was presented at SAE Annual Meeting Detroit, Jan. 10, 1951.

THE most important problems associated with low temperature lubrication of aircraft engines are of oil dilution and segregation.

To alleviate these low-temperature problems, the Air Force is developing oil tank hoppers to segregate the diluted oil from the undiluted oil in the tank.

Oil dilution is that process of the metered addition of a diluent, in this case, the regular aircraft aviation gasoline, into the engine lubricant to reduce its pour point to some desired temperature. This enables the oil at extremely low temperatures

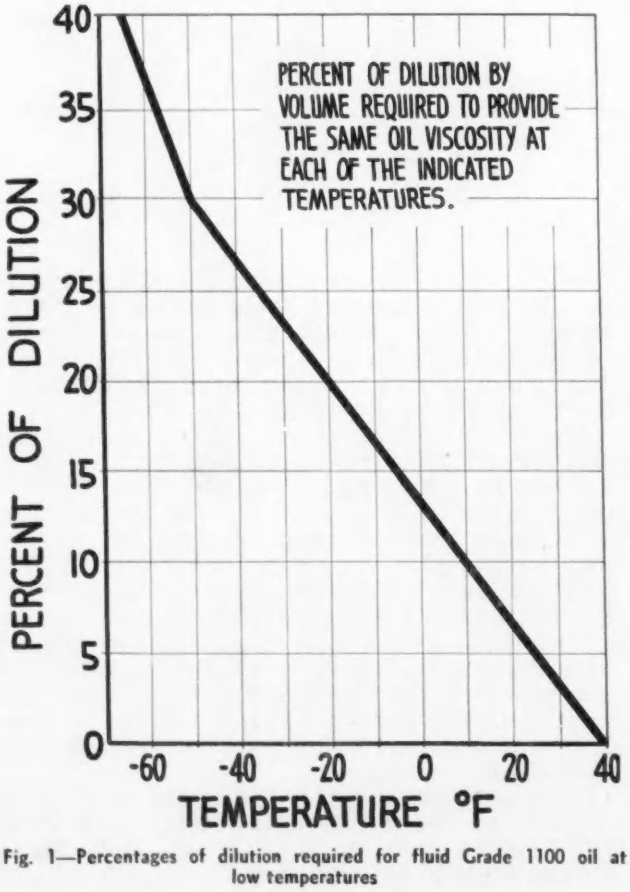


Fig. 1—Percentages of dilution required for fluid Grade 1100 oil at low temperatures

to flow to the main engine oil pump inlet and be pumped readily to various points in the engine after thorough soaking during cold weather.

Fig. 1 shows the approximate minimum amounts of dilution for obtaining good fluidity at various ambient temperatures. Thus, the amount of dilution required to obtain fluid Grade 1100 oil at any ambient temperature can be obtained at a glance. it should be noted that the curve is broken at – 50F and that 40% dilution is called for at – 65F. Years of operation and testing in the Artic have shown that operation of engines with 40% dilution at low temperatures has not harmed them.

In order to visualize the process of oil dilution of a standard aircraft engine, reference is made to Fig. 2, which is a schematic diagram of a typical reciprocating engine oil dilution system. As shown, fuel at carburetor pressure and controlled by a solenoid valve flows through a metering orifice into the engine inlet oil supply line. The point of injection has been selected so that it is the lowest-pressure point in the oil circulatory system. The oil circulatory system includes internally contained engine oil, engine inlet and outlet oil line supply, oil in the oil cooler, and oil in the tank hopper.

It has been found necessary to provide a dilution system also for the engine driven air pump (vacuum pump). The normal rate of oil flow through the air pump oil inlet passage from the engine is so slow that the diluted oil in the engine does not get to the pump during the dilution procedure, which rarely exceeds 10-12 min. Take-off from the main oil dilution system is made downstream of the normal solenoid valve, and the fuel passes through a fine mesh filter to an orifice of 0.0135 in. diameter to the air pump.

Oil dilution is normally accomplished on a time basis during the very last minutes of engine operation prior to the shutdown of the engine for an anticipated "cold soak." The duration of the diluting process is based on various factors, such as diluent flow rate, engine circulatory oil capacity, engine oil flow velocity, and percentage of diluent desired. Specification AN-T-62 is used as the basis for securing dilution time periods for standard systems.

Fig. 3 shows the results of tests conducted on standard systems. Parameters of percentage of oil

Temperature Lubrication

dilution, engine rpm, main oil pressure, engine oil temperature, cylinder head temperature, and OAT have been plotted from a representative oil dilution test on a B-29 aircraft equipped with R-3350-57 engines. Dilution was begun at 1100 engine rpm and 48 C oil temperature. During the dilution run, rpm was maintained constant at 1100. As the percentage of oil dilution was increased, the viscosity of the oil decreased with a consequent drop in oil pressure from 70 psi at 0 dilution time to 50 psi at the end of 3 min of dilution. Oil temperature rose to about 60 C. The dilution switch was released at the end of 3 min, and the engine then was operated for an additional 10–15 sec prior to shutdown to preclude the possibility of a concentration of gasoline at its point of injection (at the "Y" drain) and also to insure homogeneity of the oil.

Samples of oil were taken from the tank top and bottom, engine oil outlet, and "Y" drain. This sampling process required about 5 min per engine. The engine was then restarted, dilution being resumed at once and continued for an additional 6 min, totalling 9 min in all. By engine shutdown, oil pressure had dropped to 38 psi, and oil temperature was 50 C.

Note the irregularity of the dilution results. In 9 min, the average among the "Y" drain, engine oil outlet, and tank top was only 22%. This is consid-

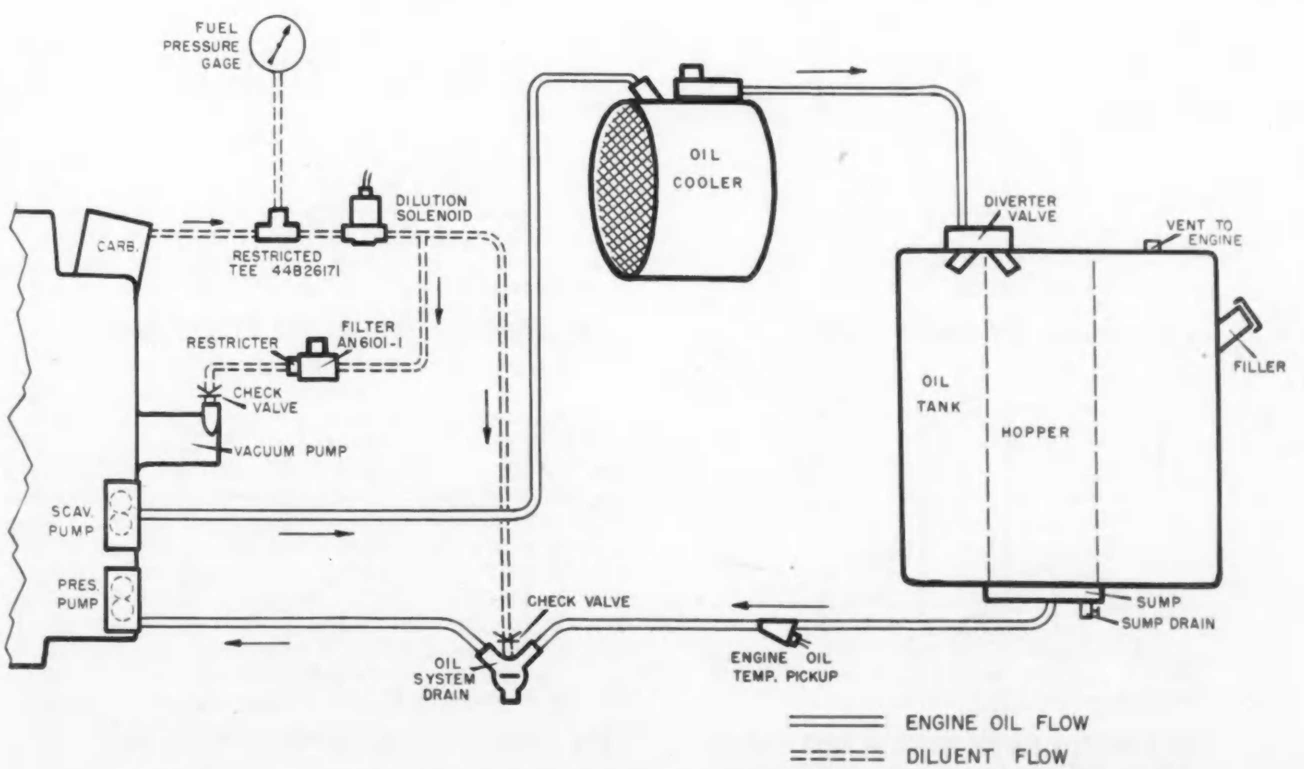


Fig. 2—Standard USAF oil dilution system, including vacuum pump oil dilution installation and oil tank diverter valve

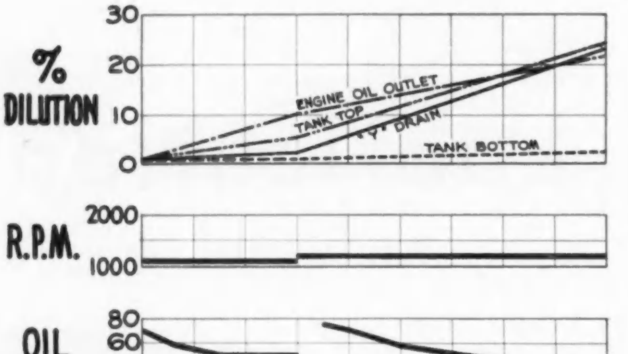


Fig. 3—Typical oil dilution test data obtained with B-29 aircraft with non-segregating oil tank

ered unsatisfactory for these reasons:

1. The dilution period was too lengthy for an attainment of only 22%.

2. Very poor segregation was obtained as shown by the tank top sample. This condition of poor segregation has created the necessity for development of the segregator oil tank as described below.

The basic function of the hopper oil tank installation of aircraft is to satisfactorily segregate the diluted oil in the circulatory oil system from the undiluted oil surrounding the hopper in the oil tank, for dilution and warm-up purposes. Unsatisfactory segregation is a hinderance to satisfactory low temperature operation in that it prevents attainment of the dilution percentage which is required to reduce the viscosity of the oil and thereby provide the necessary oil fluidity at the ambient temperatures encountered by aircraft.

Because of unsatisfactory segregation, the Air Force initiated a development program designed to eliminate this condition. Fig. 4 shows the development of oil tanks over a number of years.

The early designs consisted of a hopper placed in the tank with a free make-up oil path from the tank to the hopper. Numerous tests have conclusively shown its inadequacy as described above in the case of a typical B-29 aircraft oil system. During the dilution process there is an interchange or mixing of oil, via the free make-up path at the bottom of the hopper, between the circulatory oil system and the tank reserve oil. After shutdown, diffusion may take place, all of which is further

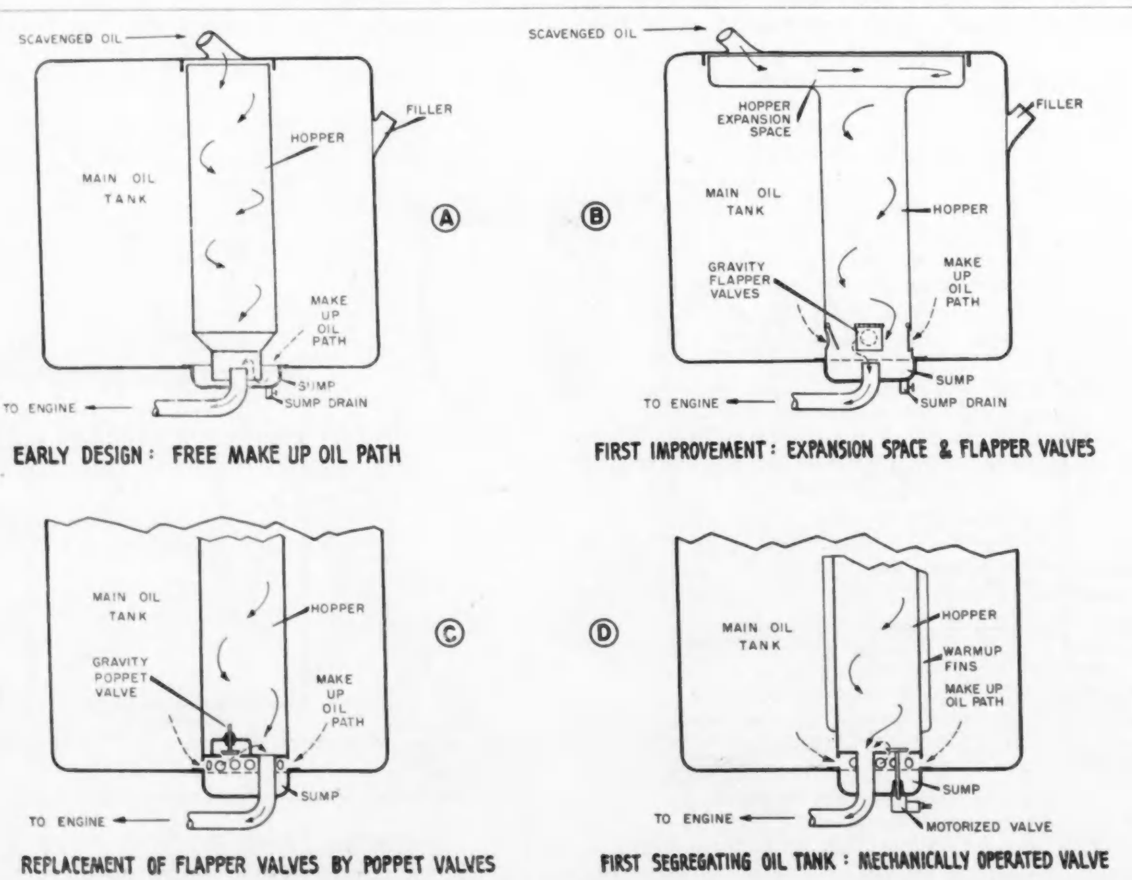


Fig. 4—Stages in the development of oil tanks for low temperature operation

aggravated by servicing of the oil tank with dense cold oil. Thus it is known that satisfactory and positive isolation of the hopper from tank reserve oil must be provided.

The first improvement, as shown, included an expansion space above the hopper, and gravity-operated flapper valves at the base of the hopper. It was originally believed that the addition of diluent would cause filling of the expansion pan and prevent any undiluted tank oil from entering the circulatory system, because of the differential head of oil existing between the hopper oil and tank oil. The flapper valves were designed to eliminate mixing of oil between the hopper and tank after engine shutdown as well as maintain the separation after engine shutdown. This design, as proved by tests, did not alleviate the condition.

An improvement in the system was then attempted by replacing the flapper valves with poppet type valves. This also failed to assist the program.

The Air Force then turned to what it at first considered undesirable—the mechanically operated segregator valve. Prototypes of an early version were tested on a B-29, a B-50, and a laboratory oil system installation, which showed that the principle was both sound and practical, and at the same time provided design data necessary for further development. The results of testing of the first segregator oil tank are shown in Fig. 5. Note the regularity and consistency of dilution throughout the circulatory oil system.

As a result of these early tests, two types of segregator valves have been selected for consideration. One type would incorporate a spring which would be compressed by an electric motor at engine starts, and thus force the segregator valve to open as soon as the oil decongealed in its vicinity. The other type would include a design whereby an electric motor would actually force the valve to open as soon as the ignition switch was operated. A detailed schematic sketch of the spring-operated segregator valve appears as Fig. 6.

With this type of segregator valve, the actual opening movement of the valve would be performed by means of a spring. This spring is attached to the stem of the valve. When the dilution switch is operated, the motor closes the valve and compresses the spring. The motion of the valve would be caused by the worm screw, which is operated by the electric motor. The valve would remain closed with the spring under tension during the dilution process and soaking periods.

When the engine is being started, the motor would be operated by the starter switch, and would draw the control shaft rod away from the valve stem. The only force holding the valve in place would then be that exerted by the heavy oil. As soon as the oil in the immediate vicinity of the valve decongealed, the spring would take over and force the valve to the fully opened position.

A system of red and green indicator lights would be used with this type of valve to provide a means of observing the position of the valve for take-off purposes. Only one red and one green light should be used per oil tank, even with two segregator valves per tank.

For successful operation in the Arctic, the Air Force research and development program has been guided toward the goal of starting engines and accomplishing take-off of the aircraft at minimum expense of time and effort. Current reciprocating engines, with standard priming systems, using regular aviation fuel, cannot be started below 0 F unless preheated. Thus deficiencies in the oil dilution system have generally been compensated for through the use of profuse quantities of external preheat. Today, investigations are progressing to the point where it may be standard procedure to start engines throughout the low temperature range

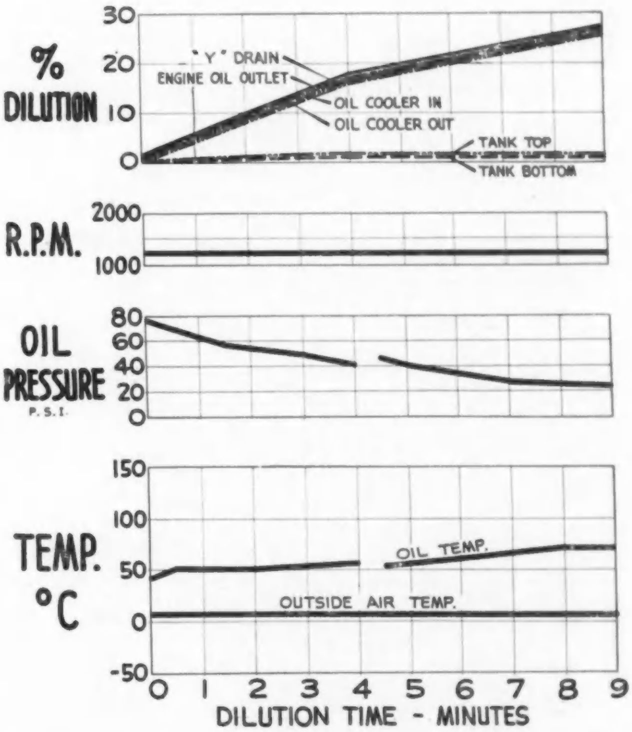


Fig. 5—Typical oil dilution test data obtained with B-29 aircraft with segregator oil tank

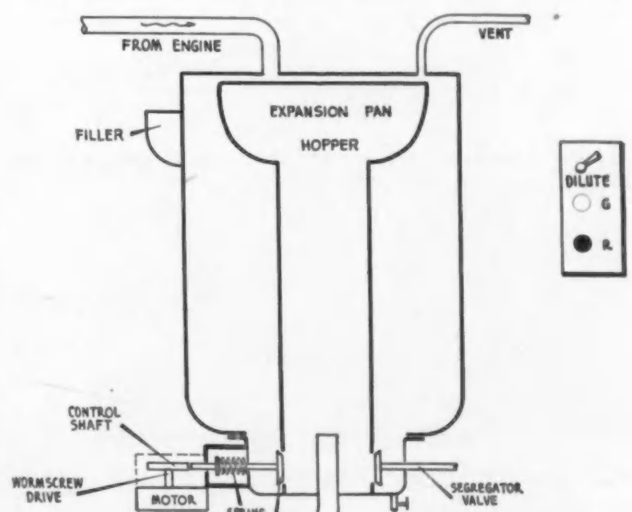


Fig. 6—Motor-operated spring-loaded type of segregator valve installation

to -65F without having to resort to any preheat whatsoever. Under such operating conditions, the oil system would have to be entirely self-sufficient. Dilution would have to be accomplished efficiently; this requires an oil tank of the segregator type.

With a good segregator oil tank installed in the aircraft oil system, adequate fluidity of the oil is insured when started at extreme low temperatures. With a system of this nature, the engine will have an ample supply of fluid lubricant until the diluent has evaporated and the remaining oil in the oil circulatory system starts to become depleted. At this point, a sufficient quantity of reserve oil surrounding the hopper must have decongealed at a rate sufficient to meet the demands of the engine. Because of this requirement, the problem resolves into one of heat transfer during the warm-up run.

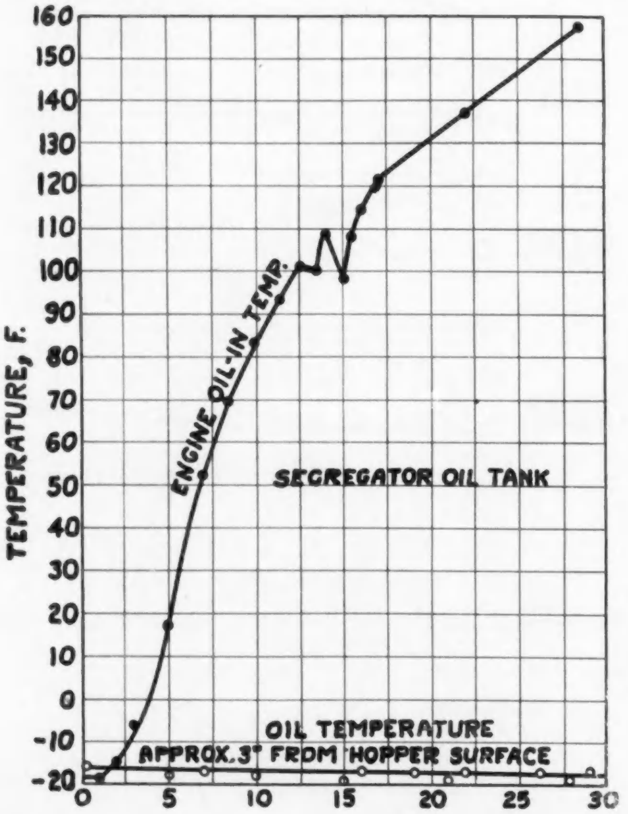


Fig. 7—Oil tank warm-up curves at - 20 F for an R-4360 engine using the segregator oil tank

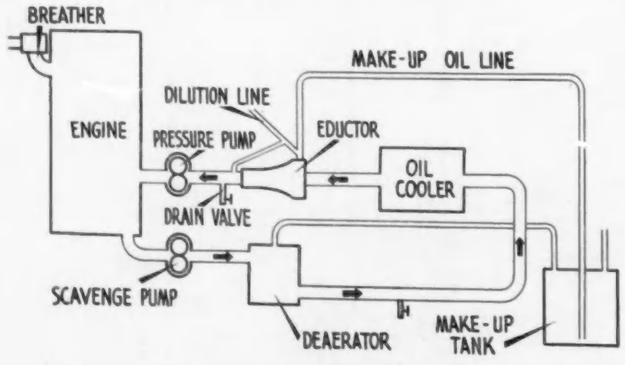


Fig. 8—Closed circuit oil system

Heat must be transferred from the oil circulatory system to the tank oil surrounding the hopper.

Since very few cryogenic data are available on the heat transfer characteristics of cold undiluted oil, the problem has been attacked by means of cold room work. The investigation is being accomplished on an R-4360 engine equipped with a segregator oil tank, where the hopper is surrounded by undiluted oil.

Tests in the cold room have shown thus far that the rate of heat transfer through the smooth wall of the conventional hopper is so slow that after a 30 min run had been made on the system following a thorough cold soak at -20F, no heat was transferred farther than 3 in. outside of the hopper walls. See Fig. 7. It is presently planned to modify the hoppers and obtain heat transfer coefficients from the different configurations. This equipment will be modified by such means as the attachment of fins, various methods of oil line routing, and annular heating compartments.

From these experiments, the heat transfer coefficients can be calculated and compared for obtaining the optimum design. The work itself is entirely novel and it is believed will supply the first basic data on this type of investigation.

The closed circuit oil system represents the most recent development in regard to aircraft powerplant oil systems. This system is primarily designed to insure that the inlet presure to the main engine oil pump will be sufficiently high even with great increase of altitude, by means of the engine scavenge pump boost. As shown in Fig. 8, this system utilizes an eductor and a deaerator in a direct circuit between the engine scavenge pump and main engine oil pump by removing the oil tank from the circulatory oil system. Make-up oil enters the system by means of a connection between the oil tank and the eductor. The eductor is of the venturi type, in that the velocity of oil flow through it reduces the pressure in it below the atmospheric pressure existing in the oil tank, thus permitting make-up oil to come from the oil tank. The deaerator is located at the outlet side of the scavenge pump and vents into the oil tank. The oil cooler has been placed between the deaerator and the eductor.

The closed circuit system has never been cold-tested on the jet engine, but cold room tests are in progress with it installed on a reciprocating powerplant. In the cold room, it has been found that the problems which have been experienced have essentially resolved into those of oil dilution and heat transfer. Since Grade 1100 oil must be diluted 40% by volume with gasoline to be fluid at -65F, the make-up oil to the eductor from the oil tank as well as the circulatory oil system must be diluted to provide flow when the engine is started. The undiluted oil in the tank must receive heat in order to be available for make-up. To accomplish these two objectives, various types of hopper design are being investigated. It is expected that final tests will be made with the modified equipment in the very near future.

(Paper on which this abridgment was based is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)

KING Gets '51 Beecroft Award

RUDOLPH F. KING, Registrar of Motor Vehicles of the Commonwealth of Massachusetts, received the 1951 SAE David Beecroft Memorial Award on Traffic Safety at the opening session of the President's Highway Safety Conference in Constitution Hall on June 13.

The presentation was made by SAE President Dale Roeder before a capacity audience of more than 4000.

King won this fifth Beecroft Award for his able administration of traffic safety in Massachusetts and his long interest in safety education. He is executive director of the President's Conference this year and has served as President of the Eastern Conference of Motor Vehicle Administrators. In 1948 and 1949 he was Speaker of the Massachusetts House of Representatives. He has been State Registrar since 1944.

The Beecroft Award was established in the will of the late David Beecroft to honor men who have served the cause of highway safety with distinction. A pioneer editor of automotive trade magazines, Beecroft was SAE President in 1921 and for a number of years was the organization's treasurer.

Chairman of this year's Beecroft Memorial Award Committee is SAE Past President James M. Crawford.

Serving with him are Pyke Johnson, president of the Automotive Safety Foundation; John M. Gleason, representing the International Association of Chiefs of Police and Police Chief of Greenwich, Conn.; DeWitt C. Greer, representing the American Association of State Highway Officials and State Highway Engineer of Texas; A. W. Magee, Motor Vehicle Administrator of New Jersey; H. S. Fairbank, Deputy Commissioner of the Bureau of Roads, U. S. Department of Commerce and Robert F. Black, of White Motor Co., representing the Automobile Manufacturers Association.

In making the presentation President Roeder said in part:

"The David Beecroft Memorial Award is dedicated to recognition of those individuals who have made outstanding contributions to safety on the highways. It was created in 1946 under the terms of the will of the SAE Past President, whose name it bears. Since that time four awards have been made. A fifth is to be made here today.

"Two of the past winners are on this platform today, Thomas H. MacDonald, Commissioner of the U. S. Bureau of Public Roads, and Sidney Williams of the National Safety Council. Arthur T. Vanderbilt, Chief Justice of the Supreme Court of the State of New Jersey, could not be present because of very important judicial commitments which could not be changed. The first recipient of the Award, Paul Gray Hoffman, is prevented from attendance today only by his absence in Europe.

"The conditions under which the Award is granted require only that the recipient write a lecture on that segment of safety work with which he has been identified.

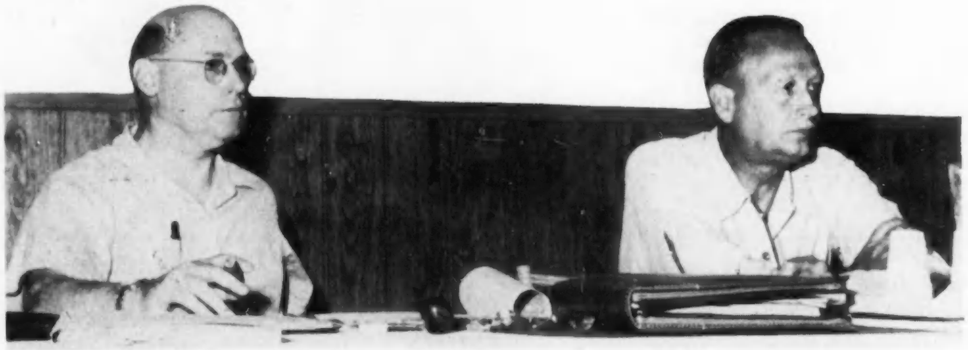
"The monographs which have resulted, however, have proved to be of great significance in the fields of public support, highway administration, traffic court procedures and research. As a result, the Past Presidents Advisory Committee of the Society has approved a recommendation from the Beecroft Award Committee that in the further selection of candidates a conscious effort should be made to produce documents of similar value, on such other outstanding phases of the Action Program as enforcement, education, information, engineering and vehicle administration.

"Later these 10 monographs will be bound and distributed as a lasting textbook on best practices in the total field of highway safety.

"Today's award carries that purpose one step forward. The recipient has been chosen from the field of motor vehicle administration. As the Registrar of Motor Vehicles in the State of Massachusetts he has made a fine contribution to the uniformly low rate of death on the highways of that State. As Director of the President's Highway Safety Conference during the past three years, giving freely of his time and services without compensation, he has added to his own stature and made a further notable contribution to safety over and beyond the line of duty. "

At SAE Summer Meeting

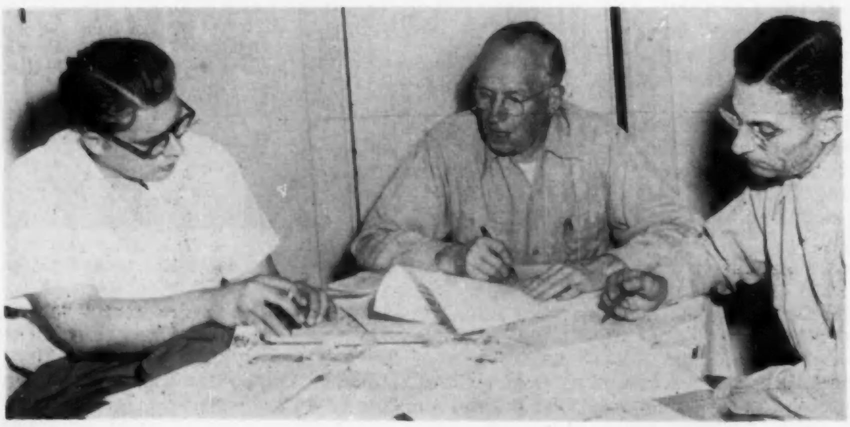
MORE THAN 35 technical and administrative committee meetings were held during the 1951 Summer Meeting at French Lick. The total number of man-hours of serious work on fruitful projects involved in these committee meetings alone ran over 1000 for the week.



D. J. Bonawit (right), chairman, Brake Subcommittee II, and Jack V. Bassett

Linn Edsall (left), vice-chairman for meetings, presiding, and T&M Vice-President J. A. Harvey at meeting of Transportation and Maintenance Activity Committee

Gavin Laurie, chairman of Load and Dimension Limitations Subcommittee of Truck and Bus Activity Committee



George C. Vahrenhold (center), chairman of Brake Subcommittee V with members Sid Tilden, Jr., and F. C. Hile

On these pages are shown a few of the leaders at these committee sessions. Many others, along with them, spent hours of concentrated effort in development of action and policies of benefit to the SAE in general and to the industries in which its members work.

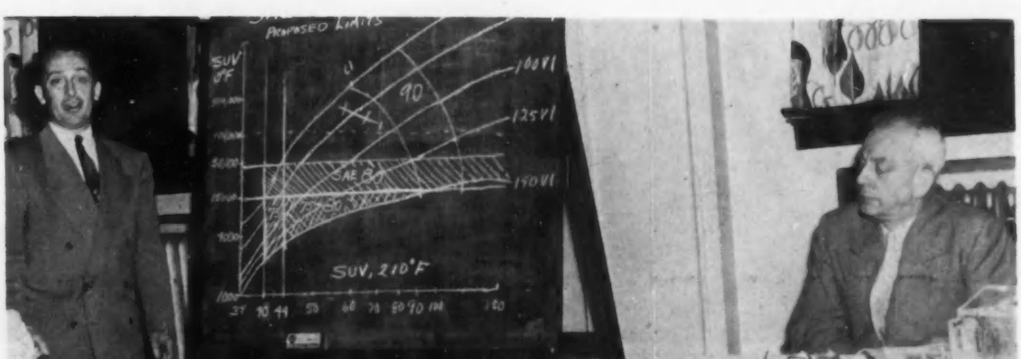
At SAE Summer Meeting

Fred B. Lautzenhiser, chairman, Engineering Formulas Subcommittee of Transportation and Maintenance Activity Committee

J. D. Klinger, chairman, Fuels and Lubricants Subcommittee A on Transmission and Axle Lubricants

J. W. Pennington, vice-chairman for meetings, presiding at meeting of Diesel Engine Activity Committee

G. A. Delaney (left), sponsor, and R. E. Carlson, chairman of Lighting Committee



C. M. Heinen (left) and M. D. Gjerde, chairman, Fuels and Lubricants Technical Committee

Largest Summer Meeting Bids French

Continued from Page 17

lies in being the first on the market with the best engineered product . . . but interchange of engineering knowledge puts the whole industry ahead.

So designers freely indulged in the pleasure of talking shop about recent accomplishments in engine design in two sessions and about design philosophies and refinements in automatic transmissions in a third session.

In other technical sessions, engineers met in a spirit of cooperation to hear what Army Ordnance may ask industry to produce in the way of wheeled military vehicles, to exchange ideas on reducing the knocking harm of combustion chamber deposits, and to describe advanced techniques in machine design.

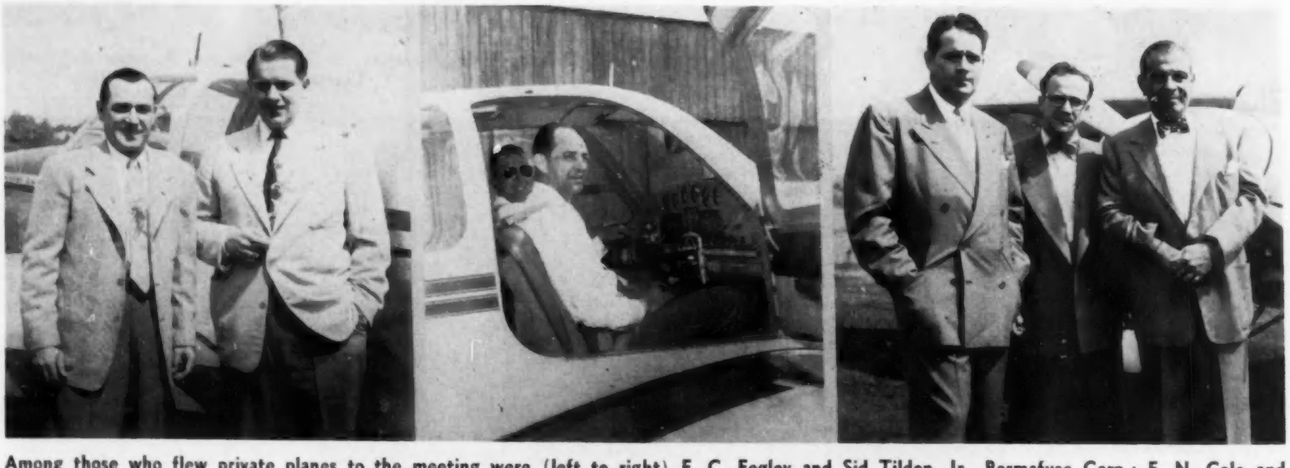
Engines

Pride of Studebaker's engineering team, their new V-8 valve-in-head engine, was described as a 7.0 to 1 compression ratio engine producing 190 lb-ft maximum torque at 2000 rpm and 120 bhp maximum at 4000 rpm. Fuel economy is good over the entire speed range. And the V-8 weighs 5% less than the 6-cyl engine it replaced.

Some of the design details disclosed about this new Studebaker engine were:

- Main and connecting-rod bearings are of micro-babbitt.
- Main journals of the crankshaft overlap the crankpins by 5/8 in.
- Vibration dampers are used for greater smoothness, although deflections due to torsional vibration would not be excessive without dampers.
- Piston pins are clamped in the rods.
- Inner rings are used with the oil rings.
- Pistons have been designed so that compression ratio may be raised to 8.5 merely by increasing the thickness of the piston head.
- Spark plugs are not pocketed, as they are in the Studebaker 6-170.
- Combustion chambers are completely machined.

SAE Air Corps at French Lick Maneuvers



Among those who flew private planes to the meeting were (left to right) F. C. Fegley and Sid Tilden, Jr., Permafuse Corp.; E. N. Cole and H. F. Barr, Cadillac Motor Car Division, Cleveland Tank Plant; and R. D. Kemp, Arthur Dulzo, Allen Industries, Inc., and Jack Gordon, Gordon-Chapman Co.

Lick Adieu

SAE's First Lady for 1951, Mrs. Dale Roeder, and President Roeder on the balcony of their Presidential Suite at the Summer Meeting

Hydraulic lifters are not used, a questioner was told, because even though their absence results in a variation in timing, no serious troubles were encountered.

In answer to a question on comparative costs, listeners learned that while it probably costs Studebaker more to produce the V-8 engine than their inline six, the V-8 saves enough car length so that the overall cost of the car is less with the new engine.

The Studebaker engine is a production engine. The Cummins JSX discussed at another session is an experimental diesel characterized as a step toward the development of a commercial engine of more power and less weight than current automotive diesels. This 401 cu in. displacement engine delivers 345 bhp at 4000 rpm and weighs only 840 lb. This is the engine developed from a Cummins truck engine in only five months to power the Cummins Diesel Special race car in the 1950 Indianapolis race. There are no plans for production of the lightweight engine, it was reported, although the truck engine has been in use since about the time of the 1950 race.

Discussers interpreted air consumption curves to indicate that the breathing of the engine is excellent. They agreed with the speaker that mechanical friction—and not breathing losses—limits diesel power output at high speeds. One diesel expert attributed economy in pumping partly to the relatively low gas velocities in this engine designed without resort to induced swirl or squish. This exchange led another member of the audience to suggest that maybe Cummins has achieved swirl in this engine without consciously designing for it. His experience was that small changes in clearance volume contour can change swirl velocities by hundreds of rpm.

Listeners who asked about the lubricating oil used with this engine were told that commercial nondetergent oils served. During the last half of the development program, it was an SAE 10 oil.

Competitors agreed with Cummins that lighter engine parts and higher speeds resulting in improved diesel power-weight ratios definitely are feasible. But designers felt that before they achieve higher speeds they will need to know more about mechanical friction and heat losses in high-speed diesels.

Automatic Transmissions

Although the principles of fluid couplings and torque converters have been known for over 40 years, there is still plenty of competition in applying them, the Monday evening symposium on automatic transmissions proved. The competition lies in trying to strike the best compromise between such conditions as smoothness and ease of operation, fuel economy, first cost, and accessibility.

Comparisons of the 12 American automotive automatic transmissions in current production showed that:

- 2 passenger car units use the simple fluid coupling.
- 2 bus transmissions use pure converters of the multistage variety.
- 8 passenger car transmissions incorporate converters which can double as couplings at high speed ratios, where the reactor freewheels with the turbine.

Of the eight passenger car automatic transmissions, two converters start and run in direct drive without being locked out. Two units start in geared

DAILY SAE Revived at 1951 Summer Meeting

Published by McManus, John & Adams, the DAILY SAE was issued this year for the first time since 1930. The big Detroit advertising agency had the sponsorship of four of its clients in putting out four issues of the traditional Summer Meeting publication. The sponsoring clients were: Bendix Aviation Corp.; Adhesives & Coatings Division of Minnesota Mining & Mfg. Co.; Pontiac Division of GMC; and The Timken-Detroit Axle Co.

The Daily SAE brought news and entertainment to all the members and their wives present. It occasioned steady and favorable comment throughout the meeting

drive to provide better performance but must span a greater gap when shifting into direct drive. Two units drive through the converter without locking it out. Two lock it out after accelerating. Locking out the converter, it was pointed out, (1) avoids all loss due to slippage in driving or hill descent, (2) avoids the variation in engine speed between drive and coast, and (3) provides ability to use full engine power without calling in the converter unless desired.

Five of the eight passenger car automatic transmissions use gearing of some sort during a normal acceleration to support their hydrokinetic elements. Five use Automatic Transmission Fluid Type A. Four use fluid-to-water heat exchangers, two use direct aircooling, and two rely on radiation. Cooling requirements depend on installation and service, it was emphasized.

As for the controversy over pure couplings versus converter-couplings, one corporation, General Motors, builds both types for passenger car use, engineers were reminded. The Hydra-Matic's hydrokinetic unit is a simple converter—which type of unit is hard to beat for fuel economy. The Buick Dynaflow and the Chevrolet Power Glide are polyphase converter-couplings, having the advantage of no shifting during acceleration. General Motors also builds the pure converter—their V-type transmission—for GM Truck and Coach, it was added.

Low torque ratio converters combined with couplings offer good efficiency and are suitable for passenger cars, speakers explained in review. In buses and other vehicles where the power-weight ratio is lower than in passenger cars, high-torque-multiplication units are needed. These units are combined with gears for efficient power transmission at high speeds.

Adherents of each design philosophy announced refinements in their respective products. Soon to appear in Hydra-Matics is a new variable-capacity pump that adjusts its output to the momentary needs of the transmission. Allison has switched from fabricated turbine assemblies to single-piece cast aluminum turbines, and the same has been

Continued on Page 70

Under the general chairmanship of **E. H. Kelley**, the following served as chairmen of the eight technical sessions of the 1951 SAE Summer Meeting: **M. C. Horine, F. K. Glynn, C. J. Livingstone, P. C. Ackerman, W. J. Pelizzoni, R. P. Atkinson, Harold Nutt**, and **L. Ray Buckendale.**

This report is based on discussions and nine papers . . . "Military Wheeled Transport Vehicle Requirements—Types of Trucks and Components Required" by **Col. W. A. Call,** Ordnance Corps, Detroit Arsenal . . . "Talented Transmissions" by **J. T. Bugbee,** The Texas Co. . . . Symposium—Automatic Transmissions and Torque Converters: **W. B. Herndon,** Detroit Transmission Division, GMC; **A. H. Deimel,** Spicer Mfg. Division, Dana Corp.; **P. R. Youngs,** Schneider Mfg. Corp.; **R. M. Schaefer,** Allison Division, GMC; **O. K. Kelley,** Engineering Staff, GMC; **F. R. McFarland,** Packard Motor Car Co.; and **D. T. Sicklesteel,** Detroit Gear Division, Borg-Warner Corp. . . . "Possible Mechanisms by which Combustion Chamber Deposits Accumulate and Influence Knock" by **L. F. Dumont,** E. I. duPont de Nemours & Co., Inc. . . . "Effects of Combustion Chamber Deposits on Octane Requirement and Engine Power Output" by **J. B. Duckworth,** Standard Oil Co. (Ind.) . . . "Calthrop's Streamlined Train—1865" by **Harold Van Doren,** Industrial Designer . . . "The Experimental High Speed Cummins Diesel Engine: 4000 rpm—345 hp—401 cu in." by **N. M. Reiners** and **R. C. Schmidt,** Cummins Engine Co., Inc. . . . "Studebaker V-8 Engine" by **E. J. Hardig, T. A. Scherger,** and **S. W. Sparrow,** Studebaker Corp. . . . "Methods for Evaluating Loads and Stresses for Machine Design" by **F. G. Tatnall,** Baldwin-Lima-Hamilton Corp. . . . **All of these papers will appear in abridged or digest form in forthcoming issues of SAE Journal, and those approved by Readers Committees will be printed in full in SAE Quarterly Transactions.**

Round Tables in Action

Synchronizers for Truck Transmissions
(Truck & Bus Activity)

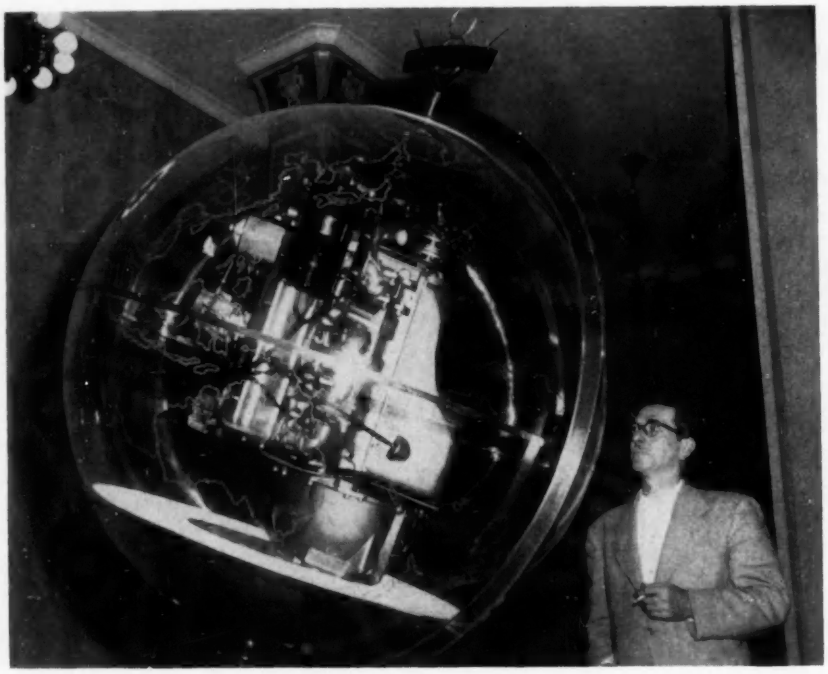
Polishing the Paint
(Transportation & Maintenance Activity)

Diesel Engine Combustion Systems
(Diesel Engine Activity)

Lubrication Problems of Aircraft Powerplants
(Aircraft Powerplant Activity)

Frame versus Frameless Bodies
(Passenger Car Activity)

Automotive Seating
(Body Activity)



E. J. Hardig looks over the new Studebaker V-8 engine of $3\frac{3}{8}$-in. bore and $3\frac{1}{4}$-in. stroke that was on display at the meeting in connection with the paper, "Studebaker V-8 Engine." Hardig, **T. A. Scherger, and S. W. Sparrow** were the authors of this paper, which discussed some of the problems encountered in the development of the engine.

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accomplished for reactors.

Ordnance engineers are very actively working to develop better wheeled military vehicles, one officer showed in previewing what automotive manufacturers may be called upon to provide for the Army. Ordnance is working simultaneously on "ultimate," ideal designs and interim vehicles improved over World War II varieties.

In its ultimate vehicles, Ordnance indicated it wants:

- Locking or semi-locking differentials, both inter-wheel and inter-axle.
- Completely sealed brakes.
- Torsion bar suspension or some other system giving increased road clearance.
- Large, soft tires.
- Automatic transmissions.

As soon as possible, these features will be incorporated in interim designs.

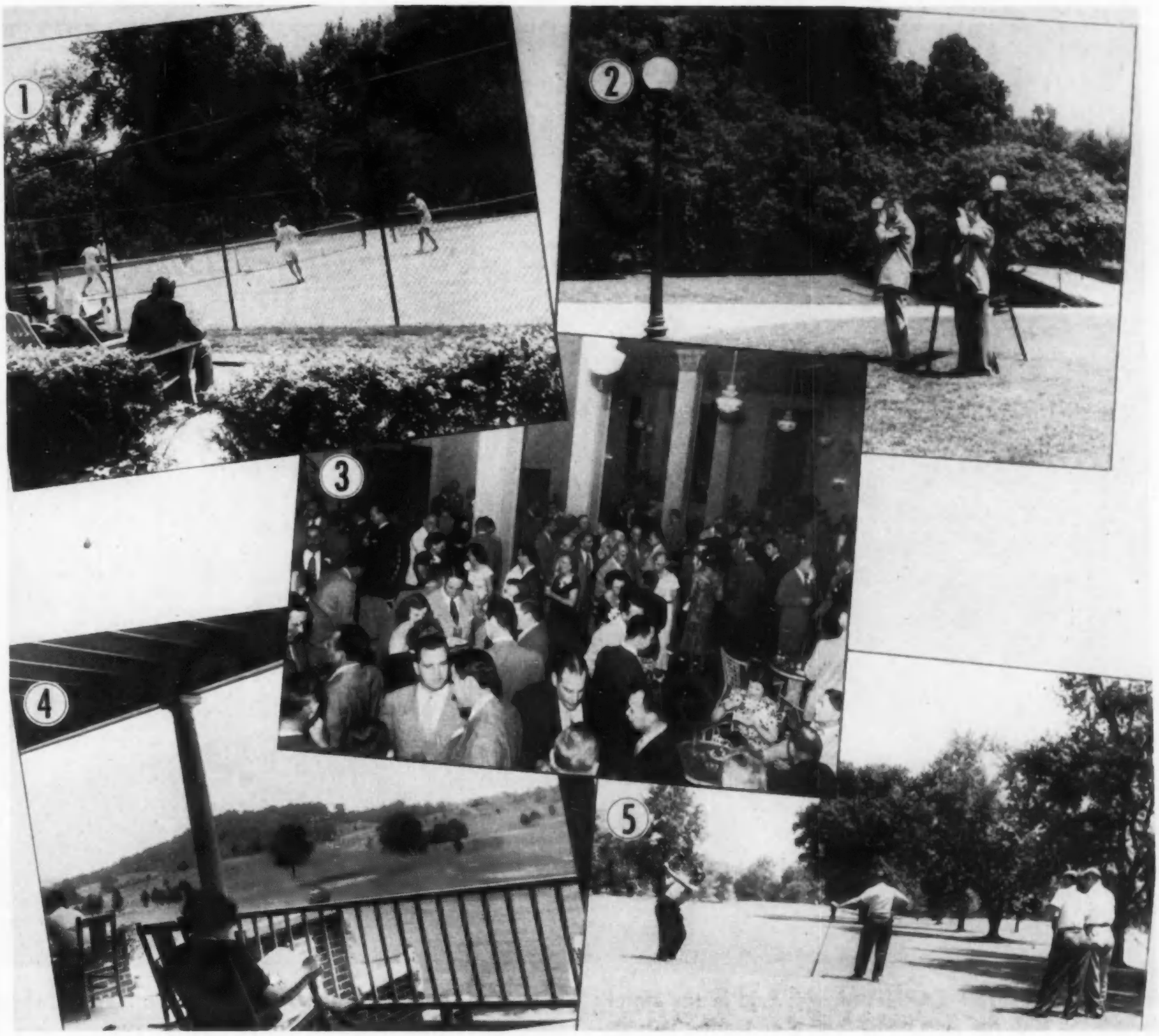
In answer to one engineer who wanted to know whether operator ability was being emphasized to reduce cost and complication of equipment, the Ordnance officer said that a compromise was being made.

A brake man pointed out to the brake manufacturers in the group that the solution to the brake

Military Vehicles

On exhibit for several days of the meeting were half-a-dozen military vehicles, shown in connection with the paper by Col. W. A. Call of Ordnance. These vehicles included the 15-ton T58 cargo truck (shown at right), $2\frac{1}{2}$-ton M135 truck, 5-ton M41 cargo truck, $2\frac{1}{2}$-ton M34 cargo truck, $\frac{3}{4}$-ton M37 cargo truck, and $\frac{1}{4}$-ton M38 utility truck

Playtime Around the 1951 Summer Meeting



1. Tennis attracted some devotees

2. Amateur photographers were numerous

3. Chatting at a party in the North Foyer

4. From the first tee at the Hill Course, where the men's golf championship was played

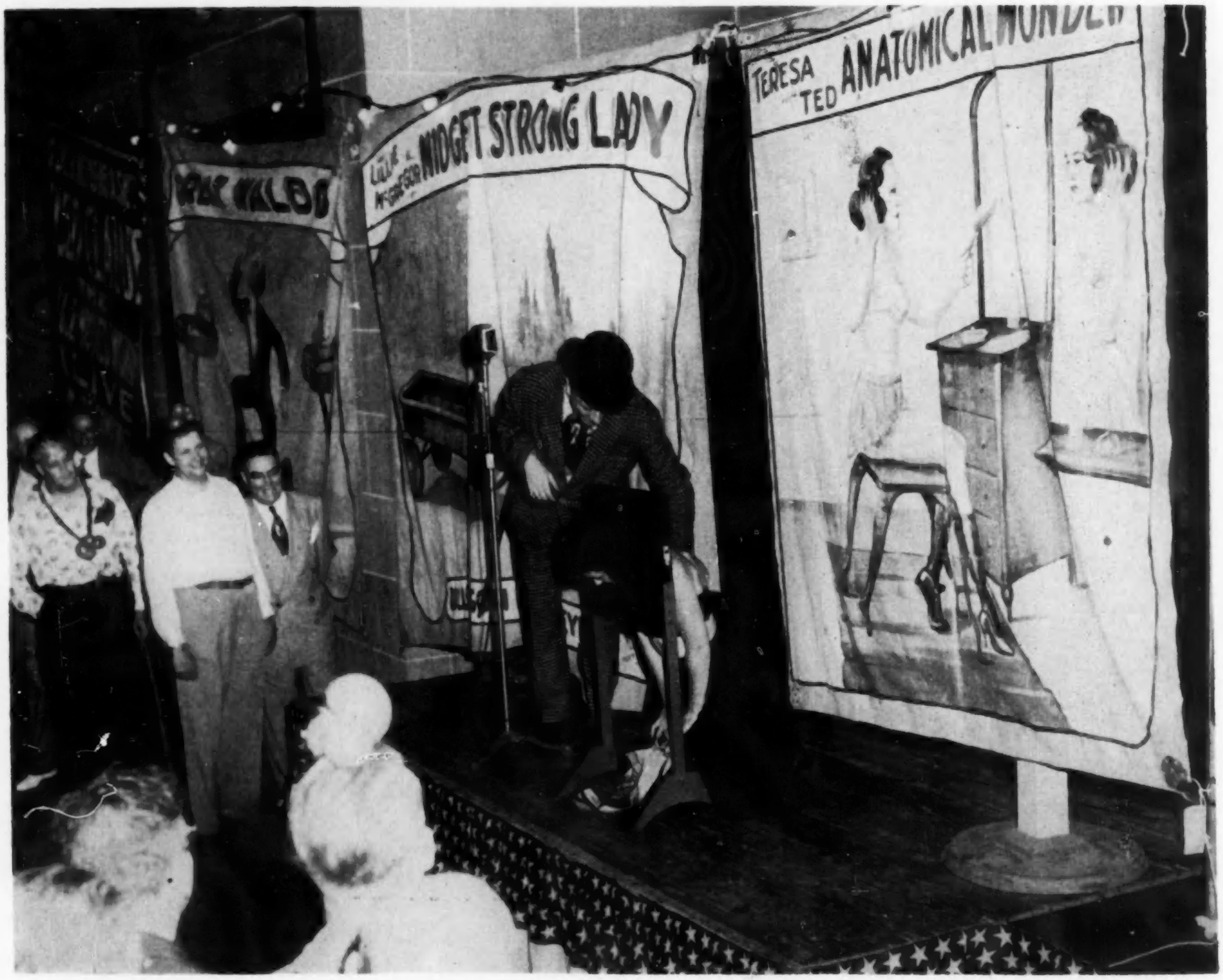
5. Starting the first hole on the Valley Course

problem would have to be a simple brake to meet service and maintenance requirements. Other engineers emphasized the importance of interchangeability of parts and ability to replace them—and complete powerplants—in short order.

In day-long discussions of the relationship between combustion chamber deposits and engine knock, tetraethyl lead was generally admitted to increase deposit formation rates but it was also universally credited with doing more good than harm.

Data were offered to show that: deposits accumulate with unleaded as well as leaded fuels . . . the more lead the greater the rate of accumulation . . . deposits flake away from time to time, probably due to thermal stresses . . . the equilibrium weight of deposits does not increase with increasing TEL content of the fuel . . . and the deposits from leaded

SAE Country Carnival



THE SAE COUNTRY CARNIVAL was held in the Hotel's Convention Hall the evening of June 6 under the Barnum-like promotion and direction of Chairman Bob Steeneck and his committee—Mrs. Steeneck, Mr. and Mrs. W. K. Creson, and Mr. and Mrs. K. R. Weise. It was a hit from the first calliope toot to the last square dance.

Members and their wives, dressed "country style," proceeded from the dining room to Convention Hall where they were greeted with "Hurry, Hurry, Hurry" from a loudly dressed and louder voiced barker who encouraged the "rubes" to rush inside to see the Greatest Show on Earth.

"The inside" proved to be all the barker claimed—fortune telling, caricaturing, "Getcher pitcher taken here,"

fuel increase octane requirement only about half as much per unit deposit volume as deposits from nonleaded fuels.

Three mechanisms were suggested by which deposits may increase octane requirement: (1) combustion chamber volume decrease, which effectively increases compression ratio, (2) thermal insulation, which raises gas temperatures throughout the cycle, and (3) catalytic effect. Various speakers and discussers presented test results indicating that the increase in compression ratio caused by deposit volume accounts for somewhere from 20 to 50% of the engine octane requirement increase, depending on the engine type and type of deposits. They were convinced also that the thermal insulating effect of deposits appears to be one of the major causes of deposit knocking harm. Opinion was divided over whether or not catalytic action of deposits con-

SAE Country Carnival

wheel of fortune, pitch 'till ya win, balloon butchers hawking their wares amid the overtones of carnival music and the nostalgic odor of fresh popcorn.

Squire Steeneck and his committee were not ones to allow the evening to slip into dawn without a few surprises. They supplied a floorshow geared to shatter all reserve and rocked the staid walls of Convention Hall, plus round and square dancing, all of which left the participants and audience gasping.

One of the clean-up crew summed up the evening's success when he was heard to mutter during the wee hours Thursday a.m. "twas quite a doins'."

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tributes to engine octane requirement.

Opinion was divided also on the questions of whether boron added to leaded fuel improves fuel octane rating significantly—and, if so, whether it does so by inhibiting whatever catalytic effect deposits may have or by changing the thermal properties of the deposits.

Deposition rates depend not only on TEL content of fuel, it was emphasized in discussion, but also on the base fuel, the lubricating oil, engine design, and operating conditions. High-additive oils decrease deposit weight but not volume, one discusser volunteered. Another explained that the smoother the combustion chamber surface, the lower the rate of deposit accumulation, but deposits do accumulate no matter how smooth the surface is.

Much of the data discussed were gathered by two experimental techniques new to many listeners: (1)

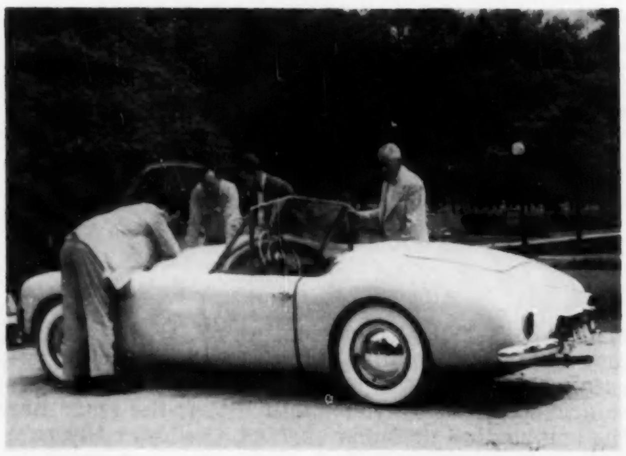
Golf Winners Get Trophies

Golf Committee Chairman Kurt R. Weise (left) presents challenge bowl and cup to 1951 SAE Golf Champion Kenneth R. Heilmann. (Heilmann carded 151 for the 36-holes to win his third successive SAE championship.). . . R. G. Wingerter (center) was runner-up to Heilmann with 159. . . Mrs. H. B. Orr (right) holds the trophy she won as 1951 SAE Women's Golf Champion, as she stands with Women's Golf Committee Chairman Mrs. Kurt R. Weise

Class A Flight (0 to 10 handicap) was won by W. B. Bassett; runner up was A. C. Bodeau. . . Class B Flight (11 to 20 handicap) was won by H. A. Beatty; runner up was Russell S. Johnson. . . Class C (21 to 30 handicap) was won by D. M. Skirving; runner up was W. W. Pennington

coatings of "Teflon," an inert synthetic, where deposits form and (2) insertion into the chamber of stainless steel washers strung on a threaded pin—both used to simulate deposit volumes.

Advanced experimental and analytical techniques were discussed also in the field of machine design. A review of the principles of application of strain gages, Stresscoat, and fatigue testing machines included a suggestion for measuring beam forces without using dummy strain gages: On a beam loaded axially, one gage is located on top of the beam parallel to the beam axis so that it is strained in tension. A second gage is placed at right angles on the same surface so that this gage is strained in compression in an amount equal to Poisson's ratio. Two other gages are placed on the opposite face of the beam to multiply output and cancel bending.



Engineers at the meeting giving a thorough inspection to the Nash-Healey sports car on exhibit on the front lawn. Engine for this car is built by Nash in this country, then shipped to England, where it is installed in rest of car built by Nash-Healey

These four gages form the complete Wheatstone bridge. Each pair gives an output proportional to the sum of unity plus Poisson's ratio. This arrangement provides temperature compensation without dummy gages because the gage in compression on top of the beam is located on the beam material at the same temperature as the live gage but the compression gage is unstressed.

An analytical technique was proposed for comparing relative stresses in various designs of bevel and hypoid gears and for estimating their fatigue life. This method differs from older methods in many ways—some of which are:

- Tooth strength is considered in the normal section rather than in the transverse section.
- Mismatch and certain experimental evidence are taken into account in determining the position of the point of load application.
- The amount of load carried by one tooth is estimated in a rational manner based on mismatch and contact ratio.
- The radial component of the normal load is considered.
- A stress concentration factor based on experimental data is applied.
- A new concept, that of "effective face width," is introduced.
- A size factor is introduced because experience indicates allowable stress varies with tooth size.
- A mounting factor allowing for the deflection of the gear mountings is included.
- No velocity factor is used. Instead, there are two impact factors, an inertia factor, and a temperature factor. These take account of the character of the prime mover and load, the accuracy of the gears, the contact ratio, and the reduction of allowable stress due to increased temperature.

An unusual angle of engineering was covered in a paper that told the astounding story of a forgotten inventor who, nearly 100 years ago, produced out of whole cloth a method of streamlining that, as the

Frequent visitors at the skeet range were (left to right): L. E. Baker, Sinclair Refining Co., Inc.; W. C. Offutt, Gulf Research & Development Co.; Fred Davis, General Motors Corp.; D. F. Caris, General Motors Research Laboratories; R. I. Potter, Standard Oil Co. (Ohio); O. J. Kelley, Cleveland Graphite Bronze Co.; John Campbell, General Motors Corp.; and J. J. Mikita, E. I. duPont de Nemours & Co., Inc.

Allison's C. J. McDowall had high score in both the 100-bird skeet and the 100-bird trap shoot in this year's reinstated skeet and trap shoot at the Summer Meeting. Since the contest rules called for only one prize to a contestant, however, first prize in the 100-bird trap shoot went to O. J. Kelley of Cleveland Graphite Bronze. First prize in the 50-bird skeet blind bogey was won by J. A. Edgar of Shell Research—and second prize by Fred Davis of GMC.

McDowall's winning skeet score was 96. F. P. Zimmerli of Barnes, Gibson & Raymond was second with 93 and R. I. Potter of S. O. of Ohio was third with 84. (Potter was chairman of the Committee responsible for the highly successful events.) Other skeet scores were: O. J. Kelley, Cleveland Graphite Bronze, 82; L. B. Gilbert, White Motor, 78; D. F. Caris, GM Research, 76; J. J. Mikita, DuPont, 58; and L. E. Baker, Sinclair, 50.

McDowall broke 85 of the 100 birds in the trap shoot. O. J. Kelley broke 75 and D. V. Walker, Consumers Co-Op Oil Co., 74. Other trap scores were: L. E. Baker, 62 and H. L. Casselman of Reo, 46.

Looking forward to a similar event at next year's summer meeting, the winner of this year's blind bogey has challenged the chairman of the skeet-shooting event to a 25-bird skeet contest using doubled-barrel muzzle loading shot guns—with sizeable donation by the loser.

author put it, "left little further to be said except as wind tunnels and the modern paraphernalia of recording instruments might have modified it."

In 1865 Samuel R. Calthrop obtained a patent with the rather ponderous title, "Improvement of Construction in Railway Trains and Cabs," for the term "streamlining" hadn't even been devised yet.

There is no doubt, though, that Calthrop knew what he was talking about. He made such definite suggestions as tapering the front and rear end of the train, putting false bottoms under the engine and cars, enclosing the platforms, sloping the windshield, eliminating projections as far as practicable.

He suggested a train, in his own words, "presenting a smooth and curving outline to the pressure of the atmospheric fluid, whereby the train may obtain a greater rate of speed with the same consumption of fuel."

He even understood the need for doors placed in the sheet-metal envelope wherever access was needed for oiling, cleaning, and the like.

Calthrop applied his ideas to a train because that was the only vehicle that traveled fast enough at that time to make any possible use of it—60 mph—but, had he lived in our age, it seems quite likely that he might have designed a P-80 Shooting Star, or a racing car for Sir Malcom Campbell.

Meeting participants cleared through "Confidential" security classification by the military services or other government agencies also heard papers in off-the-record sessions on current foreign aircraft engines, compressor inlet design and experimental development, and recent developments in the extrusion of metals.

Utilization of Higher Octane-Number Fuels

Based on paper by

W. R. GROSSER

and

H. S. KELLY

Socony-Vacuum Oil Co., Inc.

IT is not generally appreciated that the gain made in power and economy from compression ratio rise in the past 10 years is possible of near duplication if the variation in octane requirements among the cars on the road were drastically reduced.

The extent of reduction in octane requirement variation which can reasonably be expected from more careful engineering within economic limits is a matter of judgment. In our opinion it appears reasonable to suggest the following objective: that octane requirements of each make and model in the hands of car owners be held to more uniform limits such that the octane-number requirements for practical purposes be not higher than to the 50% knock-free point on the present requirement curve. This seems justified when it is brought out that many of the cars with octane requirements considerably below the 50% knock-free point show the same power and economy performance as the cars with octane requirements well above this point. Fig. 1 illustrates the case for a popular make of car designed for regular-grade fuel.

Although average octane-number requirements, as shown by the requirement to keep 50% of these cars knock-free, are now well below average nationwide regular-grade octane number, 12% of the cars require premium-grade fuel for knock-free operation.

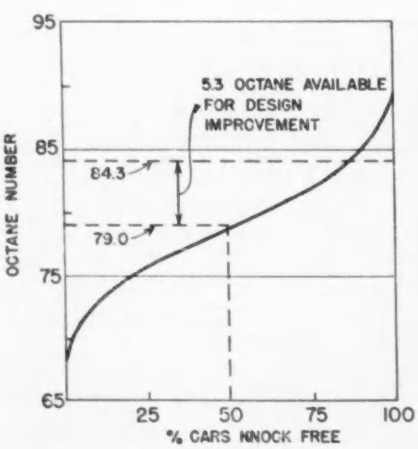


Fig. 1—Octane-number requirement to keep various percentages of a popular make of car designed for regular-grade gasoline free from knock

Consumer surveys confirm that approximately such a percentage of this make of car is using premium-grade fuel, although it has not been cross-checked that it is these same cars which exhibit the higher octane number requirement.

If the approximately 20 octane-number variation in requirement could be altered so that no significant number of these cars had a requirement exceeding the 50% knock-free point on the curve, gasoline 5.3 octane numbers below present average regular-grade quality would cover the needs of this make. Thus, the designers of this engine could increase the compression ratio without any increase in gasoline octane number over that presently available. We can estimate a 0.65 increase in compression ratio possible, giving a 3% improvement in power and economy.

(Paper, "Effect of Variation in Passenger-Car Octane Requirements on the Utilization of Motor Gasoline Quality," was presented at SAE St. Louis Section, Oct. 10, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Gaging Hydraulic Transmissions' Value

Based on paper by

R. M. SCHAEFER

General Motors Corp.

TO find out what value hydraulic transmissions have been to users, operating data were obtained from some major users, mainly in the fields of dirt moving, ore mining, and coal hauling.

By taking performance data and ownership and operating costs into account it was found that net worth of each vehicle to its operator could be established as a unit cost or cost/yard. This yardstick applies to an individual operation only, since changes in road bed, grades, type of material hauled, and the like, will affect the cost/yard.

The next step was to group together all the performance data of the vehicles for each one of the three types of operation. Then, having set up as 100% the performance and the ownership and operating costs of the vehicles with mechanical transmissions, similar data for vehicles with hydraulic transmissions were related to it.

When these data were charted, they revealed that with the higher performance of the hydraulic transmissions went greater fuel consumption, but that the ratio of work done to increased fuel consumption is favorable. Fig. 1, averaging a study of 75 comparisons

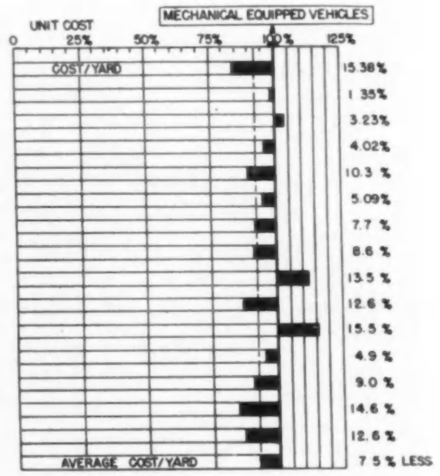


Fig. 1—Averaging a study of 75 comparisons between vehicles with mechanical drive and hydraulic transmissions, operating in various locations and services. A reduction of 7.5% in cost/yard is shown for the hydraulic transmission equipped vehicle

in various locations and services, shows an average cost reduction of 7.5% in cost/yard for vehicles using hydraulic transmissions. (Paper "Going to Work With Hydraulic Transmissions," was presented at SAE Central Illinois Section, Earthmoving Industry Conference, April 11, 1950. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Passenger Car Automatic Transmissions

LOUIS L. OTTO

Associate Professor of Mechanical Engineering, Cornell University

AUTOMATIC transmissions are now an established accessory in the passenger car field, but development and acceptance by the public was slow.

Initially, the sole purpose of a transmission (and clutch) was to help match engine output torque to demand torque. Clutch pedal operation and gear shifting, however, fatigued many drivers and, this, together with a desire to assure smooth clutch engagement and freedom from slippage wear, led to the development of the fluid clutch.

Successful transmissions were, and still are, built around fluid clutches. But each required a separate system of torque multiplication.

Simplification called for combining clutch action and torque multiplication

in a single unit. Three, four, and five element torque converters filled both requirements for normal torque demand. And planetary gears—added to the system for reverse movement—provided for maximum torque.

A large majority of present day automatic transmissions use the torque converter-planetary gear type system.

Many problems, especially those dealing with greater initial investment cost and maintenance and operation expenses, remain to be solved. But automatic transmissions are here to stay.

(Paper, "Passenger Car Automatic Transmissions," was presented at SAE Mohawk-Hudson Group Meeting, Nov. 15, 1950. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

Earthmover Speeds Create Tire Problems

Based on paper by

L. W. FOX

Firestone Tire & Rubber Co.

HIGHER vehicle speeds create one of the greatest problems for the designer of earthmover tires. Early self-powered machines travelled around 15 mph. Today's machines travel up to 35 mph and under favorable grade conditions may even exceed this. The trend seems to be to higher speeds and this has encouraged hauling longer distances which means more tire heat. Higher speeds increase the impact load and we have to use stronger materials to offset this.

Today's higher horsepower machines give better acceleration characteristics which increase the demands on tires. This has brought complaints of fast wear which have been difficult to handle in a manner to keep all parties happy. These machines have introduced another problem deserving of comment which can be illustrated best by a hypothetical example:

Suppose we have a set of conditions where a self-loading machine of an older type averages 4 mph in overall operation which includes loading, getting up to speed, dumping, starts, stops, etc. Let us suppose that under these conditions the drive tires wear out in 1500 hours service. At 4 mph we have turned in 6000 miles. As you know, the contractor's yardstick is "hours" not "miles." Now let's take a new model machine of the same type but with 30% more horsepower. Because it can get up to speed quicker and travel a few more miles per hour top speed when loaded, it does not take too

Continued on Page 116

Automatic Tappets Are Answer to Valve Lash

Based on paper by

VINCENT AYRES Eaton Manufacturing Co.

WHEN an L-head passenger-car engine was used to study valve lash variation, it was found that the intake lash change was practically negligible for all conditions of engine operation. The variation of exhaust lash at full load was 0.0025 in the speed range of 1000 to 3000 rpm with practically no change beyond 3000.

Fig. 1 shows the relation of exhaust lash and dynamometer beam load at various values of fuel flow or mixture ratio at constant speed. The greatest lash change in this engine occurred in going from idle where the setting was approximately 0.010, to full load 2500 rpm as rapidly as possible. In less than a minute more than 0.006 lash change occurred, and after several minutes a total of nearly 0.007 was reached.

To illustrate changes of higher magnitudes, an overhead valve engine of approximately 300 cu in. was tested. With lash set at 0.015 normal idle (500 rpm, no load) the throttle was opened to full load and the speed set at 3000 rpm. Within 80 sec all of the lash was taken up. After sufficient time to stabilize, the throttle was closed and the speed maintained to simulate downhill coasting. Within 100 sec normal lash was restored and in some instances was greater than the original idle setting. This indicates that with insufficient closing ramp, high seating velocities will occur with possible damage to the gear.

In studying the amount of lash at various speeds and throttle settings it was found that lash increases slightly with closed throttle as the speed changes from idle to 3000 rpm. Depending upon the throttle setting at 3000 rpm, the whole range of lash variation can be obtained under some type of operating condition. It is this type of information that can be most useful to the designer of a cam contour. He knows that in order to prevent the valve seating too hard, the ramp must be greater than the lash when operating at closed throttle, and yet he must have sufficient lash when operating at full throttle. If the engine is capable of operating at higher speeds, then these data should be established at the maximum overspeed at which the engine can be run.

In the total range of engine operation it was determined that the intake showed a maximum change of 0.005 and the exhaust a maximum change of 0.021. If you add this range and the amount required for valve gear deflection, plus an allowance for variation in the lash setting, plus a safety factor allowance to insure that the valve will not be held open, plus any allowance for valve cocking, the answer is automatic tappets.

(Paper, "Valve Lash, Automatic Tappets, and Instrumentation," was presented at SAE National Passenger Car, Body, and Materials Meeting, Detroit, March 8, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

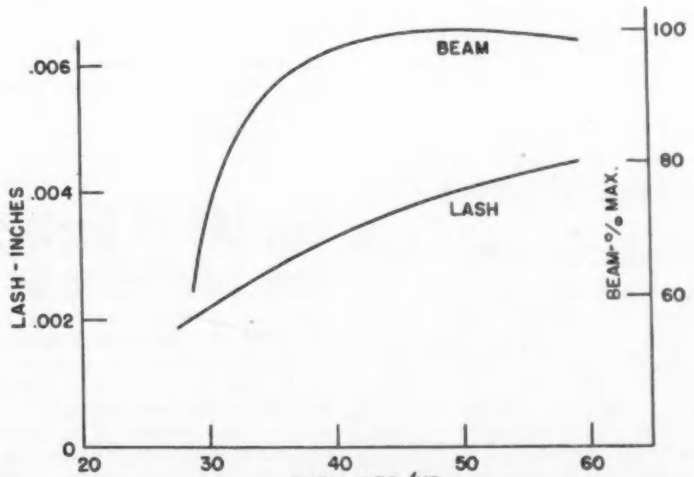


Fig. 1—Relationship of exhaust lash and dynamometer beam load at various values of fuel flow or mixture ratio at constant speed

TECHNICAL COMMITTEE *Progress*

Steel Users Hear Warning to Prepare For Replacing Alloy with Boron Steels

MAKING lean alloy boron steels work is the surest way to continue in production, builders of civilian automotive equipment were told at the June 11 meeting of the Iron & steel Technical Committee's Division VIII-Boron Steels. This report came from Ernest Hergenroether, chief of the Metallurgical Branch, Steel Division, of the National Production Administration.

Certain military programs require so much alloy that next to none is left for other products, Hergenroether said. NPA already views SAE 43XX and SAE 86XX as "high-alloy" steels. They expect that within the next few months users of alloy steels will be reduced to boron-treated carbon steels—that is, the new 14BXX series—for almost all nonmilitary and some military uses.

To speed the changeover to boron steels, Division VIII under the leadership of Chairman Harry B. Knowlton, is gathering all the information available on boron-steel experience and disseminating it through meetings, meeting minutes, and magazine articles. More than 100 attended the Division's last meeting. Some of the information presented at recent Division VIII meetings will be published in next month's **SAE Journal.**

At the June 11 meeting, Hergenroether congratulated SAE and the American Iron and Steel Institute on doing a "splendid job" of spreading knowledge of boron steels.

SAE

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New SAE 75 Grade Gear Lubrication On Way

SATISFACTORY gear shifting at temperatures of -10 F and lower would be obtainable with a proposed modified SAE 80 grade gear lubricant. Acceptance and approval of a panel report recommending revisions in the present SAE 80 grade to improve its low temperature characteristics marked the French Lick meeting of Subcommittee A—Transmission and Axle Lubricants of the Fuels and Lubricants Technical Committee.

This panel report also included recommended viscosity limits for a proposed new SAE 75 grade, designed to take care of extremely low temperature service—below that practical to handle with the proposed modified SAE 80 grade.

Submitted later in the same week to the Fuels and Lubricants Technical Committee, final action will be taken on it at the time of the National Fuels and Lubricants meeting in October.

Serving on the panel which prepared this report were: Chairman George A. Round, Socony-Vacuum Oil Co.; A. L. Clayden, Sun Oil Co.; C. M. Heinen, Chrysler Corp.; W. S. James, Fram Corp.; and W. A. Wright, Sun Oil Co.

J. D. Klinger of Chrysler has been appointed chairman of Subcommittee A, succeeding H. A. Moir, Pure Oil Co., who recently resigned his chairmanship and membership on the Subcommittee. H. L. Hemmingway, Pure Oil, will succeed him as a member of the Subcommittee.

Hydrodynamic Drive Test Code Published

THE direction sheet, log sheet, and the three curve sheets of the SAE Hydrodynamic Drive Laboratory Test Code are now available through the SAE Special Publications Department, it was reported at the June 3 meeting of the Hydrodynamic Drive Technical Committee. This committee formulated the code.

The direction sheet, Form H of the code, outlines scope, apparatus, procedure, and presentation of results. The log sheet is Form HA.

Forms HB, HC, and HD are graph sheets for plotting test results. These forms are printed on relatively transparent vellum having the graph grid in green on the back, where erasures will not destroy it. The paper is suitable for blueprinting and other common copying processes. Form HD is 11×17 in.; the others are $8\frac{1}{2} \times 11$ in.

Forms H and HA, are priced at 10¢ each sheet to members and 20¢ to nonmembers; HB and HC are 15¢ each sheet to members and 30¢ to nonmembers; and HD is 20¢ each sheet to members and 40¢ to nonmembers. Quantity prices are available on request.

Now that the laboratory test code and the SAE Recommended Practice on Hydrodynamic Drive Terminology have been approved and published, the Hydrodynamic Drive Technical Committee is working on standardization of symbols used in analysis of fluid couplings and torque converters. Since converter design is partly empirical and since different analysts use different

approaches to design calculations, the committee does not plan to standardize symbols used for such factors as design coefficients. But it does seek agreement on symbols used for such items as torque, speed, flow directions and velocities, and the quantities in the mass flow equation.

At the June 3 meeting of the committee, the subcommittee on symbols and codes received the additional assignment of developing a color code for torque converter flow diagrams.

The subcommitee is also devising a uniform type of graph sheet for plotting on one piece of paper both engine and transmission performance. Forms of this type will be printed for each of two or three general converter size ranges, it is planned.

R. P. Lewis is chairman of the Hydrodynamic Drive Technical Committee and O. K. Kelley of its subcommittee on symbols and codes.

W. B. Bergen, vice-president of Glenn L. Martin Co., recently appointed to the SAE Aeronautics Committee, top policy-making group for aeronautic technical-committee work

New T&M Special Publication Aids Selection of Trucks

A NEW and simple procedure for predicting truck performance, using accepted considerations, will soon be available as an SAE Special Publication. This report of the SAE Subcommittee on Classification and Evaluation of Transportation Engineering Formulas of the Transportation & Maintenance Technical Committee, now out for committee letter-ballot approval, is designed to help anyone concerned with the problem of truck selection.

With readily available specifications of a truck, information provided in the tables or charts of this report, and a minimum of calculation, it will be possible for a person with limited training to calculate: (1) performance obtainable from a truck of given characteristics under given operating conditions, and (2) characteristics required in a truck to meet different performance requirements under given operating conditions.

The Special Publication will include a clearly defined procedure, tables and charts from which values of operating condition can be obtained, sample work sheets, and examples of realistic problems. Other necessary values will come from truck specifications.

Chairman of this Subcommittee is F. B. Lautzenhiser, International Harvester Co. Serving with him on the committee are: M. C. Alves, Union Electric; R. Cass, White; S. Colacuori, International Harvester; L. Edsall, Philadelphia Electric; F. L. Faulkner, Nelson Chevrolet Sales; J. Gaussoin, Silver Eagle Co.; F. K. Glynn, American T. and T.; E. P. Gohn, Atlantic Refining; J. E. Hale, Firestone; W. Harrigan, William Harrigan Co.; E. N. Hatch, New York City Transit System; M. E. Horine, Mack; V. C. Kloepper, Timken-Detroit Axle; E. P. Lamb, Chrysler; L. G. Lundstrom, General Motors; E. L. Mench, Jr., Nash; M. E. Nuttila, Cities Service; J. G. Oetzel, Warner Electric Brake; W. C. Parker, Diamond T; Bart Rawson, Commercial Car Journal; H. L. Rittenhouse, Euclid Road Machinery; C. C. Saal, Bureau of Public Roads; J. L. S. Snead, Jr., Consolidated Freightways; A. F. Stamm, Chrysler; G. M. Sprowls, Goodyear; H. Stevens, American Trucking Associations; W. A. Taussig, Burlington Truck Lines; W. E. Turner, GMC Truck and Coach; and H. L. Willett, Jr., Willett Co.

Ordnance Circulates Proposed Parts Spec

THE ARMY Ordnance Corps has circulated a draft of the proposed Military (MIL) specification for "Steel: Constructional Parts for Ordnance Materiel" to all concerned Ordnance agencies. This was revealed in a letter from the Office of the Chief of Ordnance to the secretary of Division II—Ordnance Specification Review, of the SAE Iron and Steel Technical Committee.

Both Ordnance and its industry advisors anticipate that this new specification will greatly facilitate and expedite the handling of material substitutions to meet critical shortages in time of national emergency.

The draft circulated, which is the one dated 18 April 1951, is the fifth and final revision. This draft, like its predecessors, was written by Ordnance Department employees. Division II served in an advisory capacity only.

According to the letter from Ordnance, Ordnance agencies were to be allowed approximately five weeks to study the draft of the proposed specification. Their review was expected to be completed by July 1, 1951. Barring any unforeseen difficulties, the specification should issue about July 15, Ordnance indicated.

ISTC formed Division II with E. J. Hergenroether as chairman early in 1950 to undertake to secure industry opinion on the proposed specification. Division II met five times to review successive versions of the specification. Each review resulted in a revision.

Ordnance provided SAE with enough copies of the final revision to circulate to Division II, the whole ISTC, and the SAE Technical Board for review and for expression by letter ballot of approval or disapproval. Of course, Ordnance need not be bound by the SAE vote, nor is this tentative Ordnance specification proposed as an SAE specification.

The Ordnance letter expressed "appreciation for the vast amount of time, energy, and experience that members of Division II have so willingly given to the development of this specification." "It would not have been possible to bring this project to its present stage in such a relatively short time without the cooperative efforts of your organization," the letter concluded.

Engineering Project on Truck Dimensions Begins

THE Load and Dimension Limitation Committee has started work on a new project assigned to them by the Transportation & Maintenance Technical Committee. They have been asked to develop a series of Recommended Practices which will provide automotive engineering information on such subjects as the relationship between overall vehicle widths and tire sizes.

At the Subcommittee's French Lick meeting, it was decided to start the

project by considering overall widths, axle spacing of bogies, and off-tracking and turning radius in the approximate range of tire sizes from 7.50 × 20 to 14.00 × 24.

When completed, these Recommended Practices will be submitted to the T and M Technical Committee and the Technical Board for approval, prior to publication in the Handbook.

Serving on this committee with Chairman G. W. Laurie, Atlantic Refining Co., are: L. R. Buckendale, Timkin-Detroit Axle Co.; F. B. Lautzenhiser, International Harvester Co.; J. G. Oetzel, Warner Electric Brake Mfg. Co.; L. Banigan, McGraw-Hill; O. A. Brouer, Swift & Co.; M. W. English, National Highway Users Conference; J. Gaussoin, Silver Eagle Co.; B. F. Jones, Autocar Co.; G. Knudsen, Highway Trailer Co.; D. B. Olen, Four Wheel Drive Auto Co.; E. O. Sawyer, Jr., Western Motor Transport; M. C. Horine, Mack Mfg. Co.; and A. E. Williams, Freuhauf Trailer Co.

Technishorts

RECENTLY NAMED by the SAE Technical Board to represent SAE on committees where the Society is working jointly with other organizations are: Dr. Lloyd Withrow, GM Research Laboratories, to a new Subcommittee for Technical Society Liaison of the Society of Motion Picture and Television Engineers . . . Emil H. Besch, Chrysler, to succeed the late Carl Heussner as one of SAE's five representatives on ASA Sectional Committee Z26 on Safety Glass . . . A. S. Jameson, International Harvester, to succeed D. J. Giles, Latrobe Electric Steel, as alternate to L. A. Danse, General Motors, on ASA Sectional Committee B52, Materials for Tools, Fixtures, and Gages . . . G. L. McCain, Chrysler, to ASA Sectional Committee Z10, Letters, Symbols, and Abbreviations for Science and Engineering.

SAE TECHNICAL BOARD recently assigned sponsors from its membership for the following technical committees: for the Aeronautics Committee, R. D. Kelly, United Air Lines . . . for the Controlled Soil-Vehicle Testing Committee and the Tractor Technical Committee, L. A. Gilmer, Oliver Corp. . . . for the Front Wheel Alignment Tester Committee, C. T. Doman, Ford . . . for the Hydrodynamic Drive Committee, R. P. Lewis, Spicer . . . for the Iron & Steel Technical Committee, A. G. Herreshoff . . . for the Truck & Bus Technical Committee, B. B. Bachman, Autocar . . . for the Transportation & Maintenance Technical Committee, M. E. Nuttila, Cities Service . . . for the Non-Metallic Materials Committee, G. A. Delaney, Pontiac.

THE TECHNICAL BOARD has approved the recommendation of Chairman W. W. Henning, International Harvester, that the Road Test Terminology Committee be disbanded, having completed its job. This committee, set up in 1947 in response to a request from the Ordnance Dept., reviewed and revised automobile road testing terminology developed by the Automotive Division at Aberdeen Proving Ground.

PISTON RINGS: A revision in the SAE Standard for Piston Rings has been approved by the Technical Board and will appear in the 1952 Handbook. This marks the completion of a project started in June, 1949 when the Piston Ring Subcommittee first presented recommendations for changes in the standard to the Engine Committee.

GENERAL INFORMATION recently approved by the Fuels and Lubricants Technical Committee should assist automobile designers and maintenance men in the selection of lubricating greases. Prepared by Subcommittee C—Chassis Lubricants, greases are classified according to function rather than by physical or chemical properties or compositions. By emphasizing lubrication and functional requirements, this information should help prevent misunderstanding. The report is now being processed for submission to the Technical Board for adoption and publication in the 1952 SAE Handbook. C. W. Georgi, Quaker State, is chairman of the Subcommittee.

New Braking-Brake Operation Terminology

A SET of definitions covering braking and brake operation terminology has been developed and prepared by Main Brake Subcommittee No. 5. It will soon be supplemented by nomenclature which will cover various types of brakes and their component parts.

The definitions covering braking terminology—intended for Engineering use—are:

1. **The Stopping Time or Distance:** is the time elapsed or distance traveled between the instant or point at which the driver has an opportunity to perceive a demand for braking and the instant or point at which the vehicle comes to rest.

a. **The Driver Perception-Reaction Time or Distance:** is the time elapsed or distance traveled between the instant or point at which the driver has an opportunity to perceive a demand for braking and the instant or point at which the driver starts to move the braking controls.

2. **Vehicle Stopping Time or Distance:** is the time elapsed or distance traveled between the instant or point at which the driver starts to move the braking controls and the instant or point at which the vehicle comes to rest.

a. **Brake System Application Time or Distance:** is the time elapsed or distance traveled between the instant or point at which the driver starts to move the braking controls and the instant or point of first retardation by the brakes.

b. **Braking Time or Distance:** is the time elapsed or distance traveled between the instant or point of first retardation by the brakes and the instant or point at which the vehicle comes to rest.

The definitions for brake operation terminology are:

Slack: is the sum of all clearances in the braking system.

Fade: is a temporary reduction of brake effectiveness resulting from heat.

Lining Glaze: is surface hardening accompanied by reduction in friction value.

Build Up: is temporary increase of brake effectiveness.

Chairman of this Main Brake Subcommittee No. 5—Nomenclature is George C. Vahrenhold of Wagner Electric Corp.

SAE National
West Coast Meeting

Aug. 13-15
Olympic Hotel
Seattle, Wash.

MONDAY, AUGUST 13

9:00 a.m. Registration Olympic Bowl Foyer

Registration fee for technical sessions
Members, Applicants, Students and Service Men .... No fee
Other non-member guests $2.00
Note: All Technical Sessions to be held in the Olympic Bowl.

9:45 a.m.

SAE Northwest Section Welcomes SAE

ROY T. SEVERIN
Section Chairman

Acknowledgment by
DALE ROEDER
SAE President

10:00 a.m.

J. R. W. YOUNG, Chairman

Military Wheeled Transport Vehicle Requirements—Type of Trucks and Components Required
—COL. W. A. CALL, Chief, Development and Engineering Department Detroit Arsenal
(Sponsored by Truck and Bus Activity)

2:00 p.m.

W. C. HEATH, Chairman

Piston Rings and The Wear Problem
—A. J. WEIGAND, and A. M. BRENNEKE, Perfect Circle Co.
Turbosupercharging of High-Speed Diesel Engines
—N. M. REINERS, Cummins Engine Co.
Prepared Discussion on Mr. Reiners' paper by C. F. HARMS, Elliott Co.
(Sponsored by Diesel Engine Activity)

8:00 p.m.

F. O. HOSTERMAN, Chairman

The War Mobilization Situation and Its Effect on the West Coast Transportation Industry
—A. T. COLWELL, Thompson Products, Inc.
(Sponsored by Transportation and Maintenance Activity)

TUESDAY, AUGUST 14

9:30 a.m.

P. J. FAVRE, Chairman

The Where and Why of Engine Deposits
—R. S. SPINDT and C. L. WOLFE, Mellon Institute
Filtration of Fuels and Lubricants, Internal Combustion Engines—Gas, Diesel and Propane Gas
—CHARLES A. WINSLOW, Winslow Engineering Co.
(Sponsored by Fuels and Lubricants Activity)

2:00 p.m.

LYLE GARNAS, Chairman

Evaluation of Bus Requirements for City Service
—E. B. RICHARDSON, Portland Traction Co.
The Turbine Test Truck
—R. C. NORRIE, Kenworth Motor Truck Corp.
(Sponsored by Truck and Bus Activity)

6:30 p.m. Spanish Ballroom

BANQUET

GEORGE L. NEELY
Toastmaster

DALE ROEDER
SAE President

"Slow Leak—Beware"
C. M. SIMMONS
Simmons Institute of Human Relations

WEDNESDAY, AUGUST 15

9:30 p.m.

C. H. LEWIS, Chairman

Why Dual Tires Do Not Stay Matched
—H. M. PLACE, U. S. Rubber Co.
The Effect of Tire Mismatching on Lubricant Performance and Maintenance Costs of Worm Final Drives
—J. R. SCHMITT, Standard Oil Co. of Calif.
(Sponsored by Transportation and Maintenance Activity)

2:00 p.m.

E. J. McLAUGHLIN, Chairman

Final Drives for Commercial Vehicles
—N. R. BROWNYER, Timken-Detroit Axle Co.
High Additive Oils In The City, On The Long Lines, and Off The Highway
—J. A. EDGAR, Shell Oil Co., Inc.
(Sponsored by Fuels and Lubricants Activity)

About

CHARLES FROESCH has been elected vice-president in charge of engineering of Eastern Air Lines, New York. Froesch has been chief engineer with Eastern for the past 16 years, and for seven years before that he was project engineer and assistant chief engineer with the Fokker Aircraft Corp. in New Jersey.

GORDON BROWN, vice-president of Bakelite Co., a division of Union Carbide & Carbon Corp., New York City, has been elected president of the Society of the Plastics Industry.

WILLIAM HARRIGAN has gone to Washington as consultant to vice-chairman W. J. McBrian of the Supply Management Division of the Munitions Board of the Department of Defense. (John D. Small is chairman of Supply Management.)

Project on which Harrigan is engaged is coordination of four of the main agencies of the Munitions Board, namely the Standardization Agency, the Materials Inspection Agency, the Packaging Agency, and the Cataloging Agency. His address now is Barton Hall, Ohio Drive, West Potomac Park, Washington, D. C.

WILLIAM M. WALWORTH has been elected a vice-president of Reo Motors, Inc., Lansing, Mich. Walworth, former vice-president and chief engineer for Mack Trucks, Inc., joined Reo as chief engineer three years ago.

Strohl

Bosler

Whiting

Three SAE members have recently been promoted at the Autocar Co., Ardmore, Pa.: **G. RALPH STROHL**, from experimental engineer to assistant chief engineer in charge of the experimental department; **JOHN BOSLER**, from assistant experimental engineer to experimental engineer; **FRANK WHITING**, from laboratory engineer to leader in charge of the experimental laboratory.

CHARLES A. CHAYNE, GM's vice president of engineering, announces that General Motors has bought 2280 acres of desert land 34 miles southeast of Phoenix, Ariz., to be used for hot weather testing of cars, trucks, and buses. The tract will be known as the GM Arizona Proving Ground. . . . . . . **MORRIS J. MUZZY**, manager of GM's Phoenix laboratory, has been named manager of the new Proving Ground.

J. H. FRYE, general manager of sales, Columbia Steel and Shafting Co., Pittsburgh, Pa., is back with the U. S. Army Ordnance Corps in Washington, D. C., where he served during World War II. He is deputy executive officer, Office of the Chief of Ordnance.

RAYMOND C. SEEBURGER is now research physicist and bearing engineer with Hughes Aircraft Co., Culver City, Calif. Prior to this, he was a project and bearing engineer with the Mack Mfg. Corp., New Brunswick, N. J.

CHARLES KEEPERS, formerly senior project engineer with the Wayne Pump Co., Ft. Wayne, Ind., is presently production manager and general assistant to the president of the Phillips Pump & Tank Co., Cincinnati, Ohio. The company manufactures service station equipment.

OWEN D. YODER is now a co-pilot with Pan American World Airways, LaGuardia Field, N. Y. He was previously a product tester employed by International Harvester Co., Chicago. He co-pilots a Lockheed Constellation on scheduled flights from Beirut to Hong Kong.

R. E. STRASSER, who, prior to this, was a test engineer with Hydro-Aire, Inc., Burbank, Calif., is presently a development engineer with The Gates Rubber Co., Denver, Colo. He is engaged in the development of methods and procedures of producing new rubber products, evaluation of new materials and selection of proper materials for rubber products. He is field editor and section news editor of the SAE Southern California Section.

Members

Nutt

Robbins

HAROLD V. NUTT was selected superintendent of the new Fuels and Lubricants Project which has been established at the U. S. Naval Engineering Experiment Station, Annapolis, Md. Before this promotion he was technical assistant to the superintendent of the EES Internal Combustion Engine Laboratory. **WILBUR E. ROBBINS** has been selected to head the new project's Fuels Division. He was formerly head of the EES Internal Combustion Engine Laboratory's Fuels and Lubricants Branch, and has had long industrial experience in the field.

RALPH EUGENE GREY, JR., is now employed by Solar Aircraft Co., San Diego, Calif., as an experimental and development engineer. Prior to this, he was an aeronautical research scientist with the National Advisory Committee for Aeronautics, Cleveland Airport, Ohio. He is engaged in the experimental study and development of tail-pipe burners for turbojet engines.

ROBERT O. GOSE is presently with the U. S. Air Force at Vance Air Force Base, Okla. in the capacity of instructor-pilot. He holds the rank of 1st lieutenant with the 3575th Pilot Training Wing. He was previously a research engineer with Phillips Petroleum Co., Bartlesville, Okla.

RAYMOND J. LYNCH, formerly with the New Departure Division, GMC, Chicago, has been transferred to Bristol, Conn.

ROBERT J. SCHROERS is presently chief of the structures branch of the Aircraft Division of the Civil Aeronautics Administration, Technical Development and Evaluation Center, Indianapolis, Ind. Prior to this, he was an expert on International Airworthiness Standards with the CAA in Washington, D. C.

CHARLES H. McDONNELL is presently employed as a project engineer with Atlantic Research Corp., Alexandria, Va. He was previously midwest field engineer with the Specialized Instruments Corp., Belmont, Calif. He is engaged in mechanical problems concerned with jet fuel research, design, and instrumentation.

R. E. BUSEY has been appointed chief product engineer on the J-40 engine program at the new gas turbine plant of Lincoln-Mercury Division, Ford Motor Co. Busey joined Ford in 1949, as chief engineer of Ford International. He has had more than 23 years' engineering experience in the automotive industry.

ALAN G. LOOFBOURROW, chief engineer of the Chrysler Division, Chrysler Corp., Detroit, for the past six years, has been appointed assistant chief engineer of the company's Central Engineering Division. Loofbourrow entered the Chrysler Institute of Engineering as a graduate engineering student in 1935. In his new post he will be in charge of all chassis design operations.

ARTHUR H. FRIES has been appointed works manager of the Highland Park Plant of Chrysler Corp., Detroit. He has been with Chrysler since 1939, and in 1944 was made chief engineer of the Highland Park Plant, the position he has held until his present appointment.

LEONARD O. MJOLSNES has been promoted from assistant chief engineer to chief engineer of the Diesel Equipment Section of Scintilla Magneto Division, Bendix Aviation Corp., Sidney, N. Y. He has been with Scintilla since 1947.

DONALD H. McIVER has been elected to the office of vice-president in charge of industrial sales of the Ex-Cell-O Corp., Detroit. McIver was formerly sales manager of the Industrial Division of that same company.

PHILIP K. COE, right, account executive in the Goodyear Tire & Rubber Co.'s Detroit Manufacturers' Sales organization was recently presented with a service pin, marking 35 years with the company. **J. M. LINFORTH**, left, vice-president of Goodyear is making the presentation.

CHARLES A. WOLF has been appointed new sales manager of Eclipse-Pioneer Division, Bendix Aviation Corp., Teterboro, N. J. Wolf, who joined Bendix in 1936, was formerly chief sales engineer at Eclipse-Pioneer.

FRED C. HALL is vice-president and general manager of the newly-formed United Transportation Equipment Corp., located in Redwood City, Calif. The new organization is a consolidation of the Fred C. Hall Co., engaged in designing, building and selling transportation equipment used by public utility organizations in the construction and maintenance of their distribution systems; and the California Body & Trailer Manufacturers, a bus and van manufacturing business which made and sold the Allen Stordor body. The new company will develop a complete service to all utility organizations in the 11 Western states, and carry on the manufacture and sale of Allen Stordor Bodies.

W. S. COWELL has been appointed general sales manager of Atlas Asbestos Co., Ltd., Montreal, Quebec. Cowell has headed the Ferodo Division of Atlas. He is 1950-51 chairman of the SAE Montreal Section.

WARREN H. CARHART has been promoted to the position of supervisor of application engineering at the Lynwood, Calif., plant of Western Gear Works. Carhart has been with Western Gear Works for the past five years.

H. R. LOWERS, who, prior to this, was automotive development engineer with the U. S. Navy Bureau of Aeronautics, Washington, D. C., is presently chief of the Engineering Unit, Transport Vehicle Section, Automotive Branch, Industrial Division, U. S. Army Ordnance, Washington. He is engaged in the production of new tactical and commercial transport vehicles for the Department of the Army.

DAVID A. WALLACE, president of Chrysler Sales Division, Chrysler Corp., is shown with Indianapolis Speedway Queen, Loretta Young, in the Chrysler New Yorker convertible in which Wallace paced the racers to what turned out to be the fastest "500" ever driven. On June 11, Wallace received the honorary degree of Doctor of Engineering from Michigan College of Mining and Technology, where he made the commencement address to the class of 1951.

DR. K. G. MacKENZIE of The Texas Co. and **EARL BARTHOLOMEW** of General Motors Research Laboratories were among participants in the Third World Petroleum Congress in The Hague, May 28 to June 6. MacKenzie was secretary, and Bartholomew a member, of the U. S. National Committee for the Congress. More than 300 papers were presented during the 10-day meeting, which focused attention on the present status of science and technology, and the current problems in the petroleum industry. MacKenzie left April 27 for an extended tour of Europe, during which he is combining business with a study of general standardization work abroad.

LEO L. HUNTER is now sales engineer in the Manufacturers Sales Division of Perfect Circle Corp., Hagerstown, Ind. Prior to this, he was an engine testing supervisor with that same company. He is engaged in engineering and sales contacts and liaison with engine builders in the Chicago-Milwaukee area.

WILLIAM E. KELL, formerly employed by Chase Aircraft Co., Inc., West Trenton, N. J., in the capacity of senior service engineer and test pilot, is presently a powerplant design engineer with Kellett Aircraft Corp., Camden, N. J. His new position entails the design and layout of powerplant installations and component parts.

JAMES A. LeVELLE is presently a junior mechanical engineer with the Atlantic Refining Co., Dallas, Texas. He was previously a mechanical engineering instructor at Southern Methodist University.

MARTINUS RIS, JR., formerly a senior detailer with General Motors Corp., Detroit, is now a layout man with GMC at the General Motors Technical Center, Warren, Mich. He is engaged in transmission and rear axle gear design and testing.

JOHN R. PRIOR is presently employed by the GMC Cadillac Motor Car Division, Cleveland Tank Plant, Cleveland, in the capacity of project engineer. Prior to this he was a junior engineer at the General Motors Proving Ground, Milford, Mich.

ROBERT G. SMITH, previously an engineer with the Airplane Division of Curtiss-Wright Corp., Columbus, Ohio, now holds a similar position with North American Aviation, Inc., in that same city. He is working on the rehabilitation of B-29 aircraft.

J. F. AUSTIN, formerly Southwestern district manager for Deluxe Products Corp., Laporte, Ind., is now manager of the oil field and fuel division of that same company. He organizes and supervises sales to industrial and oil field supply outlets.

HERMANN L. EBERTS has been appointed to the post of purchasing agent with Canadair, Ltd., Montreal, Quebec. Eberts' previous position with the company was assistant purchasing agent.

ALFRED TOWLE, director of research and chief engineer for Anglamol, Ltd., recently received the Herbert Akroyd Stuart prize from the Institution of Mechanical Engineers. The award was for his paper on "Some Factors Governing the Performance of Crankcase Lubricating Oils," judged the best diesel engine paper given in the 1949-50 session.

FRANK X. SIELOFF has been appointed sales manager of the Elco Lubricant Corp., Cleveland, **J. E. REAGAN**, president, announced. Sieloff was engineering and executive officer aboard a destroyer escort during the war, then worked on jet aircraft engine development for Packard Motor Car Co., and joined Elco in 1949 as sales engineer.

LOUIS E. EBBS is now manager of Superior GMC Truck Sales & Service, Inc., Somerville, Mass. He was previously New England parts and service manager for GMC Truck Division.

CEYLON ROUSE, formerly a project engineer with Kaiser-Frazer Corp., Willow Run, Mich., is now a transmission and powerplant test engineer with Bell Aircraft Corp., Kenmore, N. Y. He is engaged in testing a full-scale helicopter with a dynamometer.

GUSTAV INGOLD is now chief of the ordnance technicians with the Ordnance Corps at the Preventive Maintenance Office, Aberdeen Proving Ground, Md. He was formerly chief of the Management Division, Ordnance Corps, Governors Island, N. Y. His new position entails the development and projection of preventive maintenance training material for Army Field Forces in connection with driver organizational and field maintenance on all Ordnance automotive material.

Golden

Holtzkemper

Trembath

HARRY S. GOLDEN has been appointed chief production engineer for defense contracts of the Buick Motor Division, GMC, Flint, Mich. He will fill the new position in addition to his former duties as chief production engineer for passenger cars. Golden is one of the founders of the SAE Mid-Michigan Section. **EDWARD H. HOLTZKEMPER** has been promoted to production engineer of the J-65 Jet Engine which will be built by Buick. He was formerly project engineer on passenger car engines. **ROBERT S. TREMBATH** will be production engineer for the CD-850 Tank Transmission which Buick is also building. He was formerly production engineer on the Dynaflow Transmission.

FRANCIS G. FABIAN, JR., is now a consultant with Booz Allen & Hamilton, Chicago. Prior to this, he was vice-president of Lindsay Structures, Inc., Stokie, Ill. He is engaged in engineering consulting work for clients in matters of production organization and sales.

MANTON L. SHEEHAN, formerly sales manager with the Metropolitan Supply Co., Los Angeles, now holds a similar position with The Parker Appliance Co., Cleveland.

ALFRED HASELDEN is presently a project engineer with Ford Motor Co., Dearborn, Mich. He was previously production engineer with the International Division of Ford, Highland Park, Mich. From January, 1951 until April, 1951 Haselden toured Europe, visiting automobile factories and studying their methods of production and assembly.

ROBERT H. SEMENOFF, previously a project engineer in the Powerplant Laboratory of the Air Materiel Command, Wright Field, Dayton, Ohio, now holds a similar position with the Underwater Division of the Naval Ordnance Laboratory, White Oak, Md. He designs, tests, and develops torpedo mechanisms.

FRANK B. JOHNSON is now assistant project engineer with the Georgia Division of Lockheed Aircraft Corp., Marietta, Ga. He was previously design group engineer with Lockheed in Burbank, Calif. Johnson is in charge of structures, aerodynamics, airframe design groups, and liaison.

GEORGE H. LANCASTER is presently product research engineer with the Advanced Engineering Group, Melrose Park Works, Ill. Prior to this, he was a specifications engineer with the Chicago Transit Authority, Chicago. In his new position he is working on problems connected with fuels and lubricants.

CARL D. LYNN, previously a district salesman with Shell Oil Co., Louisville, Ky., is presently a staff engineer in the lubricants department of Shell in New York City.

CHARLES A. PEEK, JR., is now a junior analytical engineer with Pratt & Whitney Aircraft, East Hartford, Conn. He was formerly a junior engineer and assistant to the chief of development with the Carrier Corp., Syracuse, N. Y. He is engaged in jet engine performance analysis.

J. F. WINCHESTER is now president and general manager of Winmesa Farms Co., Casa Grande, Ariz.

BRUCE O. TODD is presently field engineering representative in charge of the Southwest regional office of Lord Mfg. Co., Erie, Pa. Prior to this,

Continued on Page 108

OBITUARIES

HARRY A. MARCHANT

Harry A. Marchant died of a heart attack on June 7 in Detroit. He was 64 years old.

Marchant, standard parts engineer for Chrysler engineering, has served with Chrysler Corp. since its founding in 1924. He was a nationally recognized figure on thread standards and drafting practice and was active on the standardization committee which unified thread standards in the United States, Canada, and Great Britain during World War II.

Born in Aylmer, Ontario, Nov. 19, 1884, Marchant entered the automotive industry at the age of 19. He was employed by Cadillac Motor Car Co. until 1919, when he joined the engineering department of the Lincoln Motor Car Co., where he was in charge of experimental projects from 1922 until 1924. Marchant served first as production superintendent and later as chief inspector of the Paige-Detroit Motor Car Co. Joining Chrysler Corp. in 1924 as a service contact engineer, he first entered standards work in 1925. Since then his career has been highlighted by extensive committee service for various national organizations including the American Standards Association, the American Society for Testing Materials, and the wartime committees of General Motors Corp. He is survived by a son, Stewart Henry Marchant, and a daughter, Lazetta.

MICHAEL DEWAR

Michael Bruce Urquehart Dewar, chairman of British Timken, Ltd., Aston, Birmingham, England, passed away at his home Dec. 21 after a short illness. He was 64 years old.

Dewar was educated at Rugby, and Trinity College, Cambridge, and received his mechanical science tripos (honors) in 1908. He held various positions and in 1928 he assumed control of British Timken. In World War I, he served with the Royal Engineers, and then in 1940, was head of a special mission on Tanks to the United States, and was responsible in collaboration with the U. S. Ordnance for the design and production of the Sherman Tank. Later he was Deputy Director, General British Purchasing Commission and British Supply Mission till December, 1942.

He was famous for his agricultural activities, and farmed enthusiastically on a very large scale. Rugby School and Cambridge University were helped by his wise counsel. He loved the countryside, played most games well in his day, and was a first-class shot.

CARL F. LAUENSTEIN

Carl F. Lauenstein was killed May 18 in a Pennsylvania Railroad train wreck. He was 50 years old.

Lauenstein had been director of research of the Link-Belt Co., Indianapolis, Ind., since Jan. 1, and was in charge of the firm's laboratories. He had been with the company 28 years, and had been chief metallurgist for the company's two Indianapolis plants since 1936.

Born in Evansville, Ind., Lauenstein was graduated from Purdue University in 1922. He was a member of many technical and metallurgical societies and held memberships in the Country Club of Indianapolis, Indianapolis Athletic Club, and the Phi Gamma Delta Fraternity.

DAVID FERGUSSON

David Fergusson, retired chief engineer of Cunningham-Hall Aircraft Corp. who designed one of the earliest Pierce-Arrow cars, passed away unexpectedly April 27. He was 81 years old.

Fergusson was chief engineer of Cunningham-Hall and its predecessor, the Cunningham Motor Car Co., from 1923 until his retirement last year. Prior to that, he held a similar position with Pierce-Arrow. He was the designer of one of the early Pierce automobiles, the Pierce Motorette Knockabout, a representative of which won The Times-Union's Second Annual Old Car Contest. The automobile came off Fergusson's drawing board only a few months after his arrival in the United States from Scotland, where he was a designer with Argyle Motors.

A native of Bradford, England, Fergusson was a graduate in mechanical engineering of Bradford Technical College.

PIERCE A. WEYL

Pierce A. Weyl, resident engineer of the Highland Park Division, Ford Motor Co., died of a heart attack May 18. A native of Sandusky, Ohio, Weyl received his mechanical engineering degree from the University of Michigan in 1920. He served as a second lieutenant in the Army in 1918.

Weyl began his engineering career following graduation, and joined Ford Motor Co.'s engineering department in 1927. He held various supervisory positions and was chief engineer at the Rouge Plant's Aircraft Engine—Pratt and Whitney Building from 1943 to 1945. He joined SAE in 1921.

SAE Section Meetings

Ladies Night Is Outstanding Success

• Philadelphia Section

M. A. Hutelmyer, Field Editor

May 11—After spending a season reporting highly technical meetings, many of which were over his head, this field editor felt that is should be a breeze to report a "ladies night." But the evening was such a success that he finds it just as difficult to determine how to report it, so will just fall back on the old newspaper formula of Who, What, Where and Why.

Who: Philadelphia Section members in their final meeting of the season, with their wives, sweethearts and honored guests, SAE President Dale Roeder and Hollister Moore, SAE staff.

Where and What: At the Bala-Cynwyd Country Club where we wined, dined and danced.

Why: To bid farewell to the current season and have a plain, old-fashioned good time.

Roeder told us he had come to Philadelphia in anticipation of a day of golf and a pleasant evening. Unfortunately, his golf game was rained out, but the pleasant evening he undoubtedly had.

The evening started with the Society's traditional cocktail hour followed by the Bala Club's famous dinners of either roast beef or lobster Newburg, according to preference.

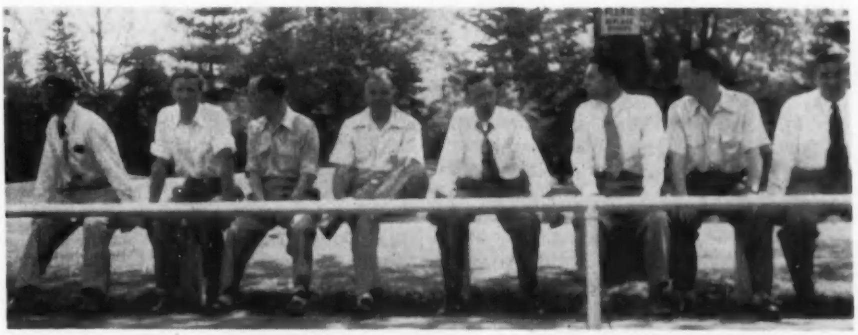
After the dinner, Chairman Laurence Cooper announced the results of the recent Section election, and introduced the officers who will manage the Section for the coming year.

Cooper then presented Roeder to the section. Roeder answered with a short talk which he directed principally to the ladies. He pointed out that the women were responsible for many of the major improvements found in the passenger car; that it was due to their insistence that most of the luxury items had reached their present high standard of perfection; that many of the improvements in the cars, such as steering column shift, color, styling, automatic transmissions and even the self-starting motor were developed because of the insistence of the ladies. He quoted from letters and articles of the early days in the Industry which showed the hardships the pioneer lady drivers had to live with, and how from these originated the demand that set many of the standards of the Industry.

After Roeder's talk, Cooper turned the meeting over to the Master of Festivities, Major C. M. Billings. Billings' program consisted of a drawing for several valuable door prizes, followed by a short motion picture on Shrimp Fishing off Lousiana, and the methods of Preparing and Serving Shrimp in the famous Antoine Restaurant in New Orleans. After the motion picture, the major presented a marvelous xylophone player.

Following her performance, dancing of all types and style was the order of the evening. We had square dancing, Paul Jones, broom dances and even Boompsa-Daisy. Of course, in addition there was also plain ballroom dancing.

In conclusion we can definitely state that everyone there felt like 16 that evening, and undoubtedly most of us felt like 90 the next day.



First-tee scene at Pittsburgh Section's annual all-day meeting at Oil City, May 16

Shown at Philadelphia Section's Ladies Night banquet are (left to right, standing): Section Secretary Elect A. M. Miley, Mrs. R. W. Donahue, Mrs. A. M. Miley and Vice-Chairman Elect R. W. Donahue; seated: Hollister Moore, Mrs. Laurence Cooper, President Roeder, Section Chairman Laurence Cooper, Mrs. Linn Edsall, and Chairman Elect Linn Edsall

Northrop Student Wins Mac Short Award

May 17—William E. Martin, (left) 26-year-old aeronautical engineering student at Northrop Aeronautical Institute, was named the first winner of the Society of Automotive Engineers' Southern California Section Mac Short Memorial Award tonight at the Rodger Young Auditorium.

The new award is to be presented annually to the student engineer who "has contributed the most to engineering during the year." It is a memorial to the late Mac Short, vice-president of Lockheed Aircraft Corp. until his death in 1948, designer of the P2V Neptune, and past SAE president.

Mrs. Mae Short, widow of the engineering executive, presented the trophy to its first recipient.

Recognition of Martin as top candidate for the award came as a consequence of selective balloting by students, faculty, and an SAE award committee. High scholarship and resourcefulness, particularly in preparing and delivering a lecture on gas turbine development, were factors in his selection.

Martin is a graduate of Beverly Hills High School and a former flight engineer and co-pilot in the Royal Canadian Air Force. He will graduate from Northrop Aeronautical Institute in December.

In announcing the award F. O. Hosterman, (center) chairman of the SAE Southern California Section, reported the trophy would be on display at Northrop Aeronautical Institute until the 1952 award winner is named. Achievement certificates went to Martin and to runner-up candidates from SAE Student Branches at other Southern California technical schools.

Hold Third Annual Ladies Night Party

• Southern New England Section

Robert E. Johansson, Field Editor

May 18—This date marks the third consecutive "Ladies Night" sponsored by the Section. With a highly successful Fifteenth Anniversary year passed into history, the now-famous outing was uppermost in the minds of those who had attended in previous years. As in past outings, the Country Club at Wethersfield, Conn. provided the setting. Some 100 persons, including members, their ladies and guests, found the event to be more than up to expectations.

The rolling fairways and intriguing greens could not help but entice some to an afternoon's golf round; however, as the social hour approached, groups began to form in the lounges with many old acquaintances renewed and new introductions made. With this for a beginning, the evening was off to a series of pleasant events. The five-course dinner featuring a choice of lobster or filet mignon really started things in that direction. Following dinner a brief business meeting enabled the tellers to report on the election of new officers and the new "team" for the coming season was introduced.

The remainder of the evening was turned over to Harry Nystrom of the American Bosch Corp. and Morgan Porter of Pratt and Whitney Aircraft who, with the assistance of their committee, had left no stone unturned to provide an outstanding occasion for all. This year two acts of entertainment were engaged featuring a breath-taking acrobatic dance routine which drew well deserved applause from even the most time-tested television viewers in the audience. Nevertheless, even those televiewers present who were anxious to see the Gavilan-Bratton welterweight championship bout were not forgotten in the planning. A large screen set was available in the lounge and many enjoyed the fine reception.

The drawing of door prizes, generously donated by leading firms in the area, is always an outing highlight and this year was no exception. Each lady received a prize as did many of their escorts. Rounding out the event, dance music was provided by one of the leading orchestras in the locality.

Reports on Development Of Gas Turbine Engine

• Spokane-Intermountain Section

G. W. Shields, Field Editor

May 16—The gas turbine was developed from the combination of principles gleaned from experiences in the steam turbine and jet engine fields, **John E. Wilson** told this meeting. Wilson, who is engaged in commercial development work for General Electric Co.'s apparatus department, told of the successful field trial of a 4500-hp unit during the past two years in freight service on a major western railroad.

Details Development Of New GM Diesel

• Northern California Section

M. H. Pomeroy, Field Editor

May 23—The rapid trend toward diesels in the trucking industry this year indicates that the future heavy-duty field will be predominantly diesel, according to **H. B. Ford** of GMC Truck & Coach Division.

Ford detailed the research and development that have gone into General Motors' 2-cycle diesel engine design. He said its design goals were high power with low weight and small size; efficiency and economy; durability, reliability; ease of driver handling; availability, low cost and ease of main-

tenance; clean exhaust; good high altitude performance; and effective engine braking on down grades.

The 2-cycle system, he said, was the only practical way of obtaining these features. He described the complicated development work required to solve problems inherent in the 2-cycle system, particularly the fuel injection system. The final design was said to be outstanding for its low weight (the 6-71 engine weights 2035 lb and the 4-71 only 1675 lb). The larger engine produces 200 hp and 600 ft/lb of torque, qualifying easily for the heavy-duty truck bracket, while the smaller engine, with 133 hp and 400 ft/lb of torque, is well adapted to the medium-heavy-duty field.

You'll Be Interested to Know . . .

GENERAL CHAIRMEN FOR THREE National Meetings were approved by SAE Council at its French Lick meeting . . . Jerome Lederer, Flight Safety Foundation, Inc., was named general chairman for next April's Aeronautic Meeting in New York . . . Robert Insley, Continental Aviation & Engineering Corp., for next March's Passenger Car, Body and Materials Meeting in Detroit . . . W. G. Nostrand, Winslow Engineering Co., for the August 11-13 National West Coast Meeting.

PUBLICATION COMMITTEE CHAIRMAN T. B. Rendel urged National Meetings Committee at French Lick to stimulate presentation of more papers to provide more material for better publications. Round tables, panel discussions and, now, security restrictions have cut number of full-length papers from about 220 to around 140 per year, he said. Publication can't properly serve the full membership with so few papers to draw upon, he pointed out, urging quality improvement as well . . . later Rendel asked a group of Section officers (1) to try to get more Section talks in written form and (2) to send copies of written papers to Publications Division at SAE Headquarters regularly.

Canada's Production Problems Discussed

• Montreal Section

Frank B. Thompson, Field Editor

May 14—Two experts reported at this meeting on the current state of Canadian industry . . . said that dwindling markets and materials shortages will force layoffs in many plants.

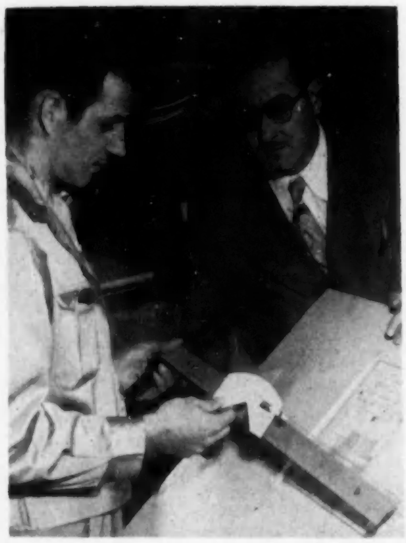
Speakers before this joint meeting of SAE Montreal Section and the Canadian Industrial Preparedness Association were Past SAE Councilor **J. C. Armer**, vice-president of the Association and president of Dominion Forge & Stamping Co., and **C. D. Howe**, minister of defense production.

Howe said that Canada cannot expect any large defense orders from the United States at the present time; that dollar shortages have made Europe a poor market; and that Canada's own requirements are small compared to the outlay involved in supplying them. To produce economically, he said, Canada must produce for the United States or for its overseas allies as well as for itself.

Howe feels that, barring an all-out war, demand for Canadian-produced defense equipment will be much smaller than during the last war. But the danger is felt to be great enough so that Canada is shifting from a state of general "precaution" to one of active "preparation," with a well-planned defense program to be carried out within the next three years.

Armer emphasized the danger in the current shortage of materials and also in higher taxes and credit restrictions. He feels it will be very difficult to take up the resulting slack for defense production. One way out for manufacturers who get defense contracts is to farm out subcontracts, and the Canadian Industrial Preparedness Association is helping the situation by making available to all government agencies and prime contractors its realistic surveys of plant facilities for defense production.

Shown at the May 14 joint meeting of SAE Montreal Section and the Canadian Industrial Preparedness Association are (left) Section Chairman Elect E. J. Cosford, vice-president of Canadian Car and Foundry Co., Ltd.; C. D. Howe, Canada's minister of defense production; and W. S. Cowell, this year's Section chairman, who presided at the dinner meeting. Right: James C. Armer, president of the Canadian Industrial Preparedness Association, past-chairman and governor of Canadian Section, and former SAE Councilor



Alvin E. Mueller (left), SAE Enrolled Student from Northrop Aeronautical Institute, shows Engineering Instructor Gordon W. Blaisdell the principle of his new method for automatically producing cross-hatch lines for engineering drawings. Mueller used a standard T-square and a 90-deg triangle attached to it by a metal channel which slides on the arm of the T-square. Its movement is produced by a rubber leg on a spring arch, which moves the triangle to set off varying spaces. A simple screw attachment regulates spaces. After a line is drawn, finger-tip pressure advances the triangle to a new position for the next line.

Mid-Michigan Hears Three Speakers

• Mid-Michigan Section

E. H. Holtzkemper, Field Editor

May 15—With today's development of electronic intrumentation the use of our natural instrumentation is too often overlooked, said **Prof. Walter Lay** of the University of Michigan at this Section's spring golf and dinner meeting.

According to Professor Lay, the efficiency of some of our present day instrumentation could be improved by proper application of some of our natural instrumentation. His point was brought out by showing how a smoke density measuring instrument was improved by substituting a glass confining tube for the common metal tube. In this way more pertinent data, such as smoke color and flow pattern, could be obtained by actual observation of the smoke sample. An additional point of illustration on display was the completely instrumented mobile test bus of the automotive laboratory of the University of Michigan.

The second speaker of the evening, **R. R. Proctor** of Pure Oil Co., described the electronic road test panel used in the Borderline method of fuel knock rating.

The Motor and Research methods of knock rating are valid only at one particular speed. The Borderline method, on the other hand, appears to give more validity to a fuel rating because it is made over a speed range, Proctor stated.

He went through the stages of the circuit development for the panel, illustrating the methods used to accurately record the engine rpm and the degree of spark advance.

The third paper "An Electronic Ignition Monitor" was presented by **R. J. Dutterer** of Hastings Manufacturing Co.

Through use of the monitor it is possible to examine every firing impulse in an engine, and it is in turn adaptable to any type of vehicle.

This ignition analyzer projects a complete diagram of the engine firing order on a cathode ray tube. The height and frequency of the voltage oscillations of the ignition system as recorded on the tube, will, with proper interpretation, indicate all types of ignition troubles, bad valves, detonation, or mal-distribution of the fuel mixture, Dutterer asserted.

Canadian Section Holds Annual Dinner

Notables at Canadian Section's annual Oshawa dinner meeting, May 18 are (left to right): J. M. Campbell, head of the organic chemistry department of GMC's Research Laboratories Division; W. A. Wecker, president of General Motors of Canada and a past Section chairman; Col. R. S. McLaughlin, president of General Motors of Canada and an SAE member since 1909; and Speaker C. L. McCuen, vice-president of General Motors Corp. and general manager of GMC Research Laboratories Division

Milwaukee

• Milwaukee Section

E. L. Conn, Field Editor

May 4—Fairbanks, Morse & Co. was host to 110 members of this Section who made a three hour tour of the Beloit works to see the manufacture of diesel engines, diesel-electric locomotives, pumps, motors, and magnetos. After the dinner, attended by 160 members and guests, three Fairbanks, Morse speakers reported on various phases of cast alloy crankshafts.

R. O. Johnson told those present that more than 6000 cast alloy iron crankshafts have been installed in varied heavy-duty diesel operation with an outstanding performance record. Development of these cast alloy shafts, with a tensile strength in the range of 60,000 psi plus, was accomplished using iron of an acicular structure with 2% nickel and 1% molybdenum. Strength of the iron used to cast the crankshafts is attributed to these factors:

1. A nickel-molybdenum alloy iron is used.
2. Raw material selection is rigidly controlled.
3. Structural composition is controlled.
4. The structure is acicular.
5. The cooling rate is controlled.
6. All phases of melting are controlled.
7. Crankshafts are low temperature heat treated.
8. Rigid specifications are maintained.

Johnson said the application of two casting principles (correct ingating and a liberal use of chills) is a considerable part of the reason for obtaining satisfactory castings. These factors, especially ingating, make it possible for the crank to solidify with a minimum amount of horizontal metal movement or disturbance.

An extremely important quality of the casting that must be maintained is the shear modulus. This, **J. D. Swannack** explained, is a necessary requirement because the torsional critical speeds must be calculated.

Comparison of several materials with relation to the longitudinal modulus of elasticity, shearing modulus and Poisson's ratio was discussed in general terms to show how cast iron compares with other materials.

Some practical methods of determin-

Continued on Page 98

Members Visit Fairbanks, Morse Plant

Milwaukee Section members during their May 4 field trip to Fairbanks, Morse & Co.'s Beloit works: (1) watching magneto housing machinery operation; (2) inspecting the Model 31, 18 × 27 dual-fuel diesel engine; (3) learning about the dual-fuel features of the large engines; (4) looking at injection pump display; (5) watching machine operation in the injection pump department; and (6) watching the laying of a large engine crankshaft in the large engine department

SAE At

SAE enrolled students at Purdue University channel their engineering into varied college and extracurricular undertakings. They take the usual field trips and draw on surrounding industries for speakers. But they are energetic in activities of the recently completed Purdue internal combustion engine laboratory, too . . . and they contributed much to insure success for last April's Engineering Open House at Purdue.

The Branch's basic aim is to supplement school work with technical information not available in books. That stimulates these outside efforts. Automotive development moves so fast, students feel, that courses can at best provide unchanging fundamentals and a touch of the practical. So Purdue Branch members are given a chance to learn first hand about what goes on in industry, to meet the men and companies with whom they will work. They get a sound basis on which to decide career areas.

Outstanding meetings in recent years have been that of March, 1948, when William B. Barnes, Charles H. Baker, and William A. Barnes presented "Performance Objectives for Transmission Design"; March, 1950, when Alex Taub delivered his paper on "Octanitus"; and September, 1950, when SAE Past-President S. W. Sparrow spoke on the development of an automotive engine.

Speakers this year have included D. J. Cummins, vice-president in charge of engineering for Cummins Engine Co.; Robert L. Stanley, educational director for the Diesel Engine Manufacturers Association; P. W. Eells, vice-president in charge of engineering for the LeRoi Co.; Karl H. Effman, research engineer for the Perfect Circle Corp.; Max Mayer, field representative of Champion Spark Plug Co.; and R. G. McMahan, automotive engineer from Socony-Vacuum Oil Co.

The students' deep interest in the new internal combustion engine laboratory was evidenced publicly in two recent open house events—the First Annual Purdue Fleet Maintenance Short Course, the engineering open house—one for SAE Indiana Section and one sponsored by the Student Engineering Council—when SAE Branch members served as demonstrators of the laboratory equipment.

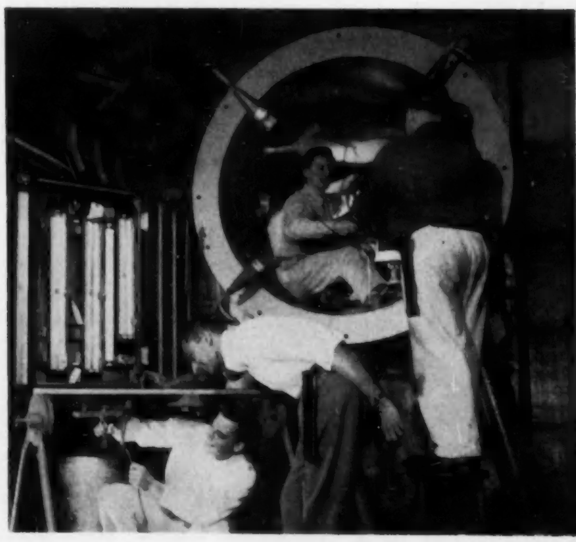
As one of the 23 member societies of the engineering council the SAE Branch sponsored all displays in the field of automotive engineering at the two-day open house in April. Most of its displays were located in and around the new internal combustion engine laboratory in the mechanical engineering building. The laboratory includes 12 engine test rooms designed for undergraduate and graduate instruction, as well as graduate research. Three graduate research projects in the field of fuels and combustion are already under way.

For the open house display, the Branch had 14 engines which are part of the regular laboratory instructional or research equipment, and illustrated the type of work being carried on regularly in the lab. These included many new passenger car engines, several diesels, and Waukesha engines for various test purposes. Also exhibited were the 11 dynamometers included in the laboratory—the largest a 2000-hp eddy-current machine. The Branch provided and installed signs to explain each piece of equipment, then contributed them to the lab as permanent fixtures.

They also showed old and new gasoline and diesel engines, most of them in operation either mechanically or by hand; a complete passenger car chassis; and an extensive automotive parts display. Considerable wall material—posters, cutaway engine drawings, and charts—helped round out an impressive display.

The SAE Branch at Purdue got its charter in 1936, under the sponsorship of Prof. H. M. Jacklin of the automotive engineering department. Prof. Joseph Liston of the School of Aeronautics took over as faculty adviser when Jacklin left the University, and since 1943 Prof. O. C. Cromer has kept the SAE wheels revolving through war and peace at Purdue.

Membership, which often has approached 200, is drawn principally from the schools of mechanical and



Left: Students working on Purdue Aero School's 9½-in. Westinghouse Turbojet engine stand. Left to right: William Mallett, Subbarao Motaparthy, Arno Kalb, and Abbott Leissler. Right: Manipulating the propeller torque reaction stand for testing full scale multicylinder engines. Left to right: Former Faculty Adviser Prof. Joseph Liston, George Hawk, Raymond Choquette, Charles Volker, and Anthony Fortini

PURDUE UNIVERSITY

aeronautical engineering, but occasionally includes electrical and chemical engineers. Many foreign students in the internal combustion engines department become members and later carry the word of SAE back to their home countries—India, Turkey, China, Brazil, Canada, and so forth.

Most SAE Enrolled Students at Purdue enter the automotive or aviation fields immediately after graduation, as shown by the "Students Enter Industry" pages of the Journal. This is partly the result of the excellent series of courses offered in these engineering fields. For the undergraduate, there are courses in internal combustion engines, automotive engineering, oil and diesel engines, and laboratory courses. Advanced courses in all phases are offered in the graduate school. In addition, the curriculum of the School of Aeronautics includes options in either aeronautical engineering or air transportation.

Over Four Hundred SAE Members Attended Purdue University—Among Them:

Richardson D. Abelson **(1942-45)**, Edward S. Agni **(1941-43, 1946-47)**, G. J. Alaback **(1942-47)**, Robert S. Alexander **(1945-48)**, John F. Amos **(1939-42)**, D. W. Anderson **(1929-33)**, J. Edward C. Anderson **(1936-40)**, R. E. Antheil **(1929-33)**, Clark S. Armstrong **(1939-42)**, Grant Hallman Arrasmith **(1946-48)**.

George Aschauer **(1934-38)**, Russell S. Atkinson **(1928-31)**, Maj. L. F. Ayres **(1945-47)**, Charles H. Baker, Jr. **(1932-36)**, Max G. Bales **(1929-33)**, W. G. Bally **(1931-35)**, C. E. Banta **(1900-04, 1911)**, Carl J. Barbee **(1925-29)**, William A. Barnes **(1945-49)**, William B. Barnes **(1916-20)**.

Loren Edward Bartling **(1938-42)**, James Carlton Bash **(1946-49)**, W. B. Bassett **(1928-32)**, R. B. Batchelor **(1940-44)**, Harrold J. Bates **(1925-29)**, William L. Batt **(1903-07)**, S. Harold Beach **(1930-33)**, William T. Bean, Jr. **(1940-42)**, R. G. Beavers **(1937-41)**, Jack Beavis **(1931-33)**.

Herman H. Bement **(1939-46)**, Charles J. Benner **(1935-39)**, George D. Bennett **(1937-42)**, M. B. Bennett **(1929-33)**, Don R. Berlin **(1917-21)**, Paul F. Bergmann **(1918-22)**, S. E. Bergstrom **(1920-23)**, Harry B. Biersdorfer **(1925-29)**, A. G. Bitzer, Jr. **(1937-42)**, M. P. de Blumenthal **(1929-33)**.

B. W. Bogan **(1927-31)**, J. A. Bolt **(1934-35)**, H. G. Bolton **(1923-26)**, Norman L. Booher **(1946-49)**, F. H. Boor **(1921-25)**, W. F. Borgerd **(1912-16)**, L. B. Bornhauser **(1933-37)**, Earl E. Borseth **(1943-46)**, George B. Bosco, Jr. **(1937-39)**, H. S. Bowen **(1935-38)**, George F. Bowers **(1919-23)**.

Hugh G. Bowles **(1934-42)**, Robert W. Boydston **(1940-47)**, Rodney L. Boyer **(1945-47)**, Charles V. Brack **(1940-43)**, Arthur M. Brenneke **(1929-30)**, Conrad L. Bresseau **(1914-18)**, Arthur E. Brown **(1946-48)**, Don L. Brown **(1915-19)**, Norman H. Brubaker **1938-40)**, J. T. Bugbee **(1924-28)**.

Arthur W. Bull **(1938-42)**, Gertrude

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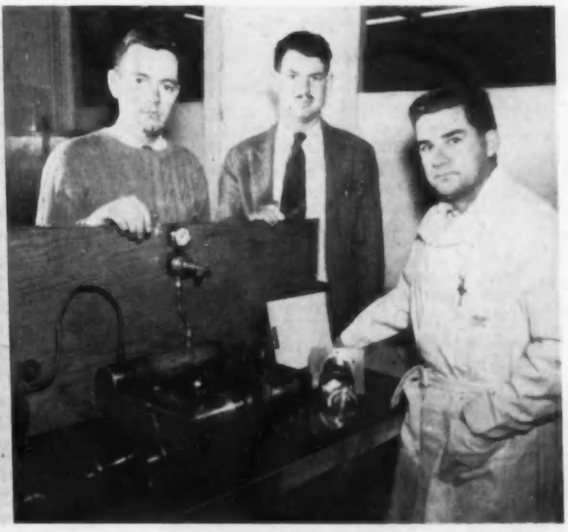

Left: Faculty Adviser Prof. O. C. Cromer points out features of a 1941 DeSoto chassis to members of an internal combustion engines class, most of whom are SAE enrolled Students. Right: Douglas Smith, Prof. V. C. Vanderbilt, Jr., and Ray Harvey with a small free piston gasifier which Harvey designed and he and Smith, both graduate students, built with Vanderbilt's guidance

Continued from Page 93

Parks Bullivant (**1944-45**), Richard T. Burnett (**1929-33**), H. J. Buttner (**1927-31**), Jack D. Bryan (**1936-40**), R. J. Cahill (**1932-36**), John F. Campbell (**1924-28**), Charles E. Capron (**1933-37**), Frederick W. Carr (**1936-38**), Nathan A. Carter, Jr. (**1932-33**).

Richard L. Cassman (**1940-42, 1946-47**), Lewis R. Catt (**1943-46**), John Paul Charles (**1921-26**), Ray T. Chevedden (**1938-40**), A. W. Christy (**1940-43, 1946-47**), M. Roger Clapp (**1937**), P. A. Clark (**1938-40**), John M. Clem (**1937-41**), John W. Cochrun (**1936-40**).

John D. Cole (**1933-37**), Jerome Collins (**1936-38**), **1947-48**), Wendell C. Compton (**1932-37**), Robert E. Conlee (**1940-43, 1946-48**), E. L. Conn (**1937-41**), Sylvan E. Connair, Jr. (**1944-45**), Warren C. Conover (**1929-33**), Edmond B. Cooper (**1941-43**), Louis M. Corbell (**1945-48**).

John B. Craft (**1938-42**), W. K. Creson (**1915-24**), Robert A. Cumming (**1943-45, 1946-48**), Pitt A. Curtiss (**1943-46**), Richard L. Dahlgren (**1943-44**), T. O. Dahlstrand (**1927-32**), Ben Daneman (**1937-40**), L. A. Danse (**1913**), John J. Daus, Jr. (**1946-49**), D. L. Davis, Jr. (**1923-28**).

Francis H. Davis (**1922-26**), James R. Davis (**1943-46**), Lewis H. Davis (**1917-23**), R. G. De Long (**1934-38**), J. K. Dickey (**1916-20**), Robert W. Donahue (**1938-41**), Floyd G. Dougherty (**1937-39**), Edward Garland Dorsey, Jr. (**1946-49**), John W. Drake (**1933-37**), William H. DuBois (**1924-28**).

Warren J. Dubsky (**1938-42**), J. B. Duckworth (**1929-36**), Robert F. Duncan (**1928-30, 1936-39**), R. L. Duncan (**1948**), Rex J. L. Dutterer (**1924-28**), William C. Edmondson (**1930-34**), Roger H. Elliott (**1935-39**), George William Ely (**1938-42**), Earle G. Fahrney (**1930-34**), Earl V. Farrar (**1926-29**).

Henry Anthony Ferguson (**1931-35**), John R. Ferris (**1938-40**), Russell Charles Fink (**1946-50**), William A. Fleming (**1940-43**), Darius S. Flinn (**1943-45**), William H. Foland (**1929-33**), A. H. Fox (**1924-28**), Walter William Frank (**1938-42**), Titus E. Frankenfield (**1927-32**), Paul E. Friend (**1940-44**), George O. Gale (**1937-42**).

K. C. Gano (**1924-28**), George S. Garrard (**1918-20**), G. A. Gemmer (**1896-99**), Fernand L. Gerin (**1916-20**), H. S. Gerstung (**1937-41**), A. H. Gilbert (**1912-17**), William M. Gilbreth (**1930-33, 1934-36**), M. D. Gjerde (**1916-19**), Clifford L. Gough (**1926-30**), Donald C. Green (**1930-34**).

Ralph E. Grey, Jr. (**1942-45**), Edward Daniels Grier (**1937-39, 1946-48**), John E. Griner (**1942-45**), Fred J. Grumme (**1933-37**), W. W. Halstead (**1932-36**), Robert L. Hartley (**1938-40**), Donald P. Heath (**1936-40**), Robert L. Heath (**1928-32**), Robert W.

Heid, Jr. (1936-47), R. C. Heidner (1939-41).

Danforth K. Heiple (1937-41), J. P. Heiss (1924-28), H. A. Helstrom, Jr. (1934-38), Frederick Hendy (1937-40), John P. Henson (1939-46), Robert K. Heule (1946-47), John B. Hiday (1922-26), William W. Higginbotham (1940-43), Donald George Hilligoss (1938-42), N. F. Hindle (1921-25).

Robert King Hirchert (1935-39), Keith B. Hocker (1937-42), Roscoe C. Hoffman (1907-11), T. B. Holliday (1923-29), Thomas W. Holt, Jr. (1931-35), Max F. Homfeld (1941-42), James H. Horton (1937-39), H. Franklin Hostetler (1944-46), Perry House (1929-33), George F. Houston (1923-27).

R. W. Hoyt (1931-35), James C. Hughes (1939-42), Fred B. Hunt (1929-31), George H. Hunt (1921-25), Leo L. Hunter (1936-40), Robert R. Hutchison (1910-13), L. L. Huxtable (1925-28), H. S. Ingersoll (1941-48), Stephen Jack (1943-45), C. H. Jackson (1933-41).

Joseph F. Jamison (1945-48), Everell Willis Jewett, Jr. (1934-38), Robert E. Johansson (1938-42), Ralph S. Johnson (1929-33), Robert E. Johnston (1947-49), C. H. Kanavel (1926-32), John A. Kany (1933-37), M. H. Kapps (1924-29), Carl L. Kepner (1935-38), Grant W. Keller (1941-44, 1946-48), R. D. Kelly (1921-25).

Thomas L. Kendall (1929-33), Robert L. Kessler (1932-36), F. M. Kincaid, Jr. (1927-32), Hugh G. Kepner (1940-47), Robert E. Klein (1938-42), E. Crowell Knight (1936-40), C. Paul Kolthoff, Jr. (1943-47), Machlin B. Laddon (1939-42), H. C. Lafferty (1939-41), C. V. Larch (1936-40).

Carl F. Lauenstein (1918-22), W. G. Lautz (1935-38), F. H. Lawson, Jr. (1940-43, 1945-46), G. R. Layden (1930-35), Edward H. Leavitt (1946-48), Arthur H. Ledyard (1944-46), Lawrence S. LeGros (1926-32), Ralph M. Lehman (1940-47), Lawrence R. Lentz (1930-34), Vernon H. Lewis (1935-39).

George J. Liddell (1921-24, 1925-26, 1931-33), Gerald D. Line (1931-35), R. M. Lipes, Jr. (1939-40, 1942-44), Joseph Liston (1924-30), Samuel R. Lloyd (1940-47), Bartholomew C. Loskot (1935-39), Richard R. Lovell (1930-34), James N. Low (1937-40, 1946-47), Stanley H. Lowy (1940-43), Clark R. Lupton (1921-30).

Frank W. Lynch (1931-35), R. A. MacGregor (1935-40), Donald C. MacMillan (1943-46), Charles S. McCarthy (1907-11), John R. McGuire (1937-41), R. G. McMahan (1929-33, 1940), N. Robert McManus (1938-42), Robert W. McNabb (1940-42), James C. McRoberts (1929-32), Charles D. Manhart (1926-30).

Donald S. Marden (1937-41), Francis J. Markey (1924-25), John M. Martin (1941-43), H. O. Mathews (1919-23), James R. May (1936-41), John W. Mazur (1935-39), A. J. McAllister (1920-24), Charles W. Messersmith (1923-27, 1936), William M.

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Meyer, III (1942-45), Joe H. Miles (1945-48), D. W. Miller (1937-41).

W. Porter Miller (1929-32), Herman E. Minneman (1929-33), R. Elmer Minton (1927-29), Bennie D. Mirkin (1939-41), Harry R. Mitchell (1935-39), John David Moeller (1946-49), LaVerne Morgan (1939-42), Donald G. Moore (1931-33, 1936-38), Norton B. Moore (1929-31), Herbert H. Moses (1935-39).

Philip C. Mosher (1946-49), Milton L. Munson (1938-42), K. L. Mulholland (1936-40), Kenneth Murdoch (1937-40), F. L. Murphy (1918-22), C. M. Murray, Jr. (1938-42), W. C. Musham (1934-38), John T. Nadolny (1943-47), Joseph L. Nemeth (1939-42), Daniel Nettesheim (1941-46).

Walter G. Newnam (1931-35), R. M. Nichols (1933-37), R. L. Oblinger (1936-40), Donald B. Olen (1931-36), A. William Orr, Jr. (1937-39), David R. Osborne (1933-34), Raymond O. Oyler (1931-36), Ceburn Parker (1930-34), Glenn H. Parker (1927-29), Leslie O. Parker, Jr. (1928-32).

C. F. Pence (1939-42), Donald C. Perkins (1926-30), Ralph W. Perkins (1934-37), W. F. Perkins (1924-28), B. C. Phillips (1921-25), Robert W. Platt (1940-44), George Poehlmann (1934-38), Albert M. Port (1930-32), Philip H. Pretz (1924-28), R. H. Prewitt (1925-29).

W. E. Rafert (1940-43), A. S. Randak (1930-34), Carlton A. Rasmussen (1937-40), Earle J. Raut (1931-33), Kenneth S. Recu (1944-48), Howard G. Reed (1925-30), N. K. Reinhard (1934-38), James C. Rhodes (1938-42), I. F. Richardson (1930-34), Robert D. Rinehart (1940-44).

John J. Riordan (1945-47), Fred A. Robbins (1934-39), Wilbur E. Robbins (1923-27), Albert O. Roberts, Jr. (1941-43, 1946-48), Robert C. Robertson (1927-31), Francis R. Rogers (1937-42), Paul H. Rogers (1933-38), William Rohr (1939-42), John William Ronan (1931-35), E. R. Ross (1915-16, 1917-20).

E. C. Roth (1907-11), Val Roper (1921-25), Dean Edward Rudig (1935-39), V. P. Rumely (1908-11), Carl L. Sadler, Jr. (1934-38), Earl V. Schaal (1912-17), R. F. Schaefer (1924-1928), Raymond A. Schakel (1918-22), John J. Schauble (1944-46), Walter W. Scheumann (1919-23).

Albert P. Schnaible (1936-41), Wilbur K. Schroeder (1928-33), F. Frank Schwilk (1914-18), Edward Ray Searby (1945-49), Henry J. Sejda (1936-41), Harold R. Sennstrom (1931-33, 1935-37), F. Herbert Sharp (1929-33), W. H. Shealor (1934-38), Thomas J. F. Sherman (1935-39), Robert A. Shogren (1943-48).

Brooks H. Short (1927-34), John M. Sickler (1922-26), Stuart J. Sietsma (1931-39), Kenneth M. Silcock (1931-34), Charles A. Siler (1937-41), Joseph Frank Slomski (1944-47), A. Edward Smick (1941), Richard Smirl (1933-35), D. M. Smith (1914-19), Elvie Laurence Smith (1947-49).

Fred C. Smith (1915-19), Gaylord E. Smith (1930-34), Harold E. Smith (1944-47), Malcolm A. Smith (1923-25), Marion L. Smith (1941-47), Raymond B. Smith (1932-36), R. Kennedy Smith (1936-42), T. C. Smith (1906-10), Warren H. Smith (1925-28), Marion L. Smitley (1938-41).

Julian Soukey (1945-48), Herman Staggenburg (1922-26), Harmon G. Stech (1933-38), Milford D. Stewart (1926-30), H. B. Stone (1933-37), Emory W. Stoner (1917-19), Seth H. Stoner (1926-29), C. E. Summers (1902-06), Walter E. Swigart (1938-42), C. Robert Talmage (1931-35).

James H. Taylor (1919-24), James R. Taylor (1918-22), S. B. Taylor (1920-24), Jackson H. Teetor (1941-43, 1946-48), Ralph J. Teetor (1903-05), Ellis W. Templin (1906-10), Richard K. Thelen (1938-43), Armand L. Theilker (1943-44, 1946), Harold W. Thomas (1931-32, 1937-39), Thomas J. Thompson (1934-41).

William A. Tooher (1937-39), James Arthur Trail (1933-34), V. A. Trask (1915-20), J. P. Tretton, Jr. (1929-30), H. A. Triplett (1936-41), Murray C. Triplett (1937-41), Vern C. Vanderbilt, Jr. (1938-42), Paul H. Van Osdol (1926-31), Joseph P. Van Overveen (1939-40), C. B. Veal (1898-1902).

Howard H. Vogel (1930-32), William N. Wainwright (1929-33), Henry H. Wakeland (1940-43, 1946), Thomas J. Wall (1941-47), F. D. Wallace (1916-22), Alexander E. Weaver (1928-32), James E. Weesner (1930-34), M. F. Weill (1927-31), R. K. Weldy (1934-37), James Wesbecker (1946-48).

Sam B. Williams (1939-42), Cyril Wilson (1913-16), H. D. Wilson (1914-19), James R. Wimborough (1932-36), Donald W. Wing (1932-33), Herman E. Winkler (1923-27), Herbert Wise, Jr. (1938-42), John G. Wood (1903-07), Walter R. Woodward (1937-43), Edgar A. Work (1924-28).

Marshall Hoyt Wright (1946-49), A. R. Wylie (1931-33), Albert W. Yates (1937-41), James E. Yingst (1940-51), Edward C. Yokel (1933-37), R. A. Young (1940-42), W. S. Zartman (1943-45), Robert M. Zimmerman (1928-32), Charles M. Zimney (1940-43, 1946-47), Paul K. Zimmerman (1938-42), George A. Zink (1925-29).

Paul C. Zmola (1941-49), August H. Zoll (1942-46), M. J. Zucrow (1924-28).


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KNURLED POINT, SELF-LOCKING SOCKET SET SCREW
KNURLED POINT, SELF-LOCKING SQUARE HEAD SET SCREW
KNURLED HEAD SOCKET STRIPPER BOLT
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FLEXLOC
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One-piece, all-metal, for maximum strength—minimum trouble. Positive, automatic locking. FLEXLOCS serve as both stop and lock-nuts. "Positively won't shake loose."
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SELF-LOCKING STOP NUT, "THIN"
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ing the values of longitudinal and shearing modulus quickly are:

1. Twisting a specimen.
2. Sound reflections method.
3. Resonance of small bodies.

One of the major disadvantages to the twist method of determining modulus, according to **R J. Maddock**, is the amount of work, and subsequent expense, necessary to test a sample. Basically the twist method consisted of loading a beam fastened to the specimen, then measuring the deflections.

The development of the electrodynamic method has resulted in a much more practical test method. The test specimen is a 1-in. diameter, 8-in. length cylinder which is machined from a coupon cast in the mold with the crankshaft. This cylinder is placed on soft rubber supports, and on one end a prod exerts a shaking force of a sine wave pattern from a transducer constructed from a high fidelity radio speaker. The driving signal is generated by an audio frequency signal generator. The response of the test bar is obtained by a crystal pick-up and transmitted to an oscillograph screen. By means of an electronic switch the generated signal and response is viewed simultaneously.

Maddock indicated several interesting factors learned from test results using the above means to establish modulus. Charts were shown illustrating the effect of carbon content on modulus and density; low carbon resulting in high density and modulus and high carbon the opposite. While the low carbon iron had a more desirable stiffness, the shafts were more difficult to machine. He pointed to the distribution of modulus for several shafts which indicated the amount of control now present, with the objective in sight to improve control and at a higher modulus if possible.

Montreal Wins Section Membership Competition

With a total of 66.1 applications for membership per hundred members, the Montreal Section took top honors in the Inter-Section membership competition for the 1950-1951 Section year, SAE Membership Chairman Orville A. Brouer reports. San Diego was second with 56.1, and the Atlanta Group third with 39.3. The three leaders were in the Featherweight Division (less than 100 members), captained by Vincent Ayres. Membership Chairmen of the winning Sections were L. F. Vaulthier, Montreal; D. S. Sanborn, San Diego, and C. E. Steed, Atlanta Group.

In the Welterweight Division (100 to 199 members), captained by V. L. Durrstein, Central Illinois Section, under Membership Chairman L. C. Bailey, finished in first position with 29.4 applications per hundred members. Winner of R. W. Goodale's Middleweights (200 to 499 members) was the Milwaukee Section with 15.4, led by Membership Chairman W. J. Adams, Jr. The Chicago Section, under Membership Chairman W. L. Rodgers, rolled up 18.9 applications for each hundred members to lead J. H. Booth's Heavyweight Division (more than 500 members).

The Society as a whole averaged 13.8 applications per hundred members in accumulating 1943 applications for the twelve-month period. This topped last year's figure of 1754 by more than ten percent and is the Society's best showing since the war years.

Hear First-Hand Report on Patton Tank

• Detroit Section

W. F. Sherman, Field Editor

May 7—A combat observer's report on the M-46 General Patton tank was given at this dinner meeting by **Major W. O. Miller**, of the Army Ordnance Corps. (Excerpts from Major Miller's paper appear on p. 26 of this issue.)

The performance of the tank has been outstanding and has provided an opportunity to appraise many new tank features, Miller indicated. He had very intimate experience with the Patton tank, having served as project engineer on it at Aberdeen Proving Ground, as special observer during large scale tests at Fort Hood, Texas, for the Chief of Ordnance and as combat observer in Korea for five months for the Detroit Arsenal. The tank, he reminded his listeners, is a converted M-26 of World War II with an air cooled engine and automatic transmission.

Its principal adversary is the Russian T-34, for which he provided some comparative specifications indicating that it is lighter in weight but more powerful, has a water-cooled engine, manual transmission and many features of simple design.

The M-46 covered the distance from

Pusan across the 38th Parallel to within 15 miles of the Manchurian border, a road distance of over 500 miles. Troops like the vehicle for its performance. They particularly like the fact that the air-cooled engine requires no anti-freeze and like to use the automatic transmission. There is appreciation of the fact that the cold processed rubber used for the tracts has tripled track life. Flexible steel oil lines have virtually eliminated oil line failure. Suspension failures have been at a minimum. However, the vehicle has been given unusual use operating and firing from positions on 60 per cent slopes in order to get good firing range over the mountains.

On the Korean roads truck springs and shock absorbers take severe punishment and there are numerous failures. Up to now winterization kits have not been good and a lot of primitive methods are used to start in cold weather.

Major Miller indicated that maintenance has been pretty well handled and that changing of power units has been accomplished in the field with the enemy only a mile away.

He expressed appreciation for services rendered by SAE to Ordnance and said that the fire power and mobility provided by the automotive industry are enabling our troops to stave off overwhelming numbers of the enemy, causing the great losses and saving our own men. He concluded with a tribute to industry—Ordnance teamwork and a wall chart in the form:

SIMPLICITY
ADAPTABILITY
EFFICIENCY
OPERATION
REPAIR
DISTRIBUTION

Dale Roeder, SAE President and a member of the Detroit Section, appeared before the members to give an appraisal of the responsibilities of SAE members in this period which is half peace and half war.

Engineers have more responsibilities in the present situation than other citizens do, he said. Moreover, automotive engineering has become a part of war strategy and production is a part of combat. He reviewed SAE contributions in World War I and World War II and outlined briefly the current SAE war projects.

This war is different from any other. The problem is to keep our economy strong, he declared. Therefore, we must build all the goods we can without interfering with defense efforts.

The speakers were presented to more than 800 members in the Rackham Memorial Building with Max M. Roensch, Vice Chairman of Passenger Car Activity, presiding.

At the meeting a desk set was presented to L. Irving Woolson, retiring chairman, by Edward N. Cole, Vice Chairman.

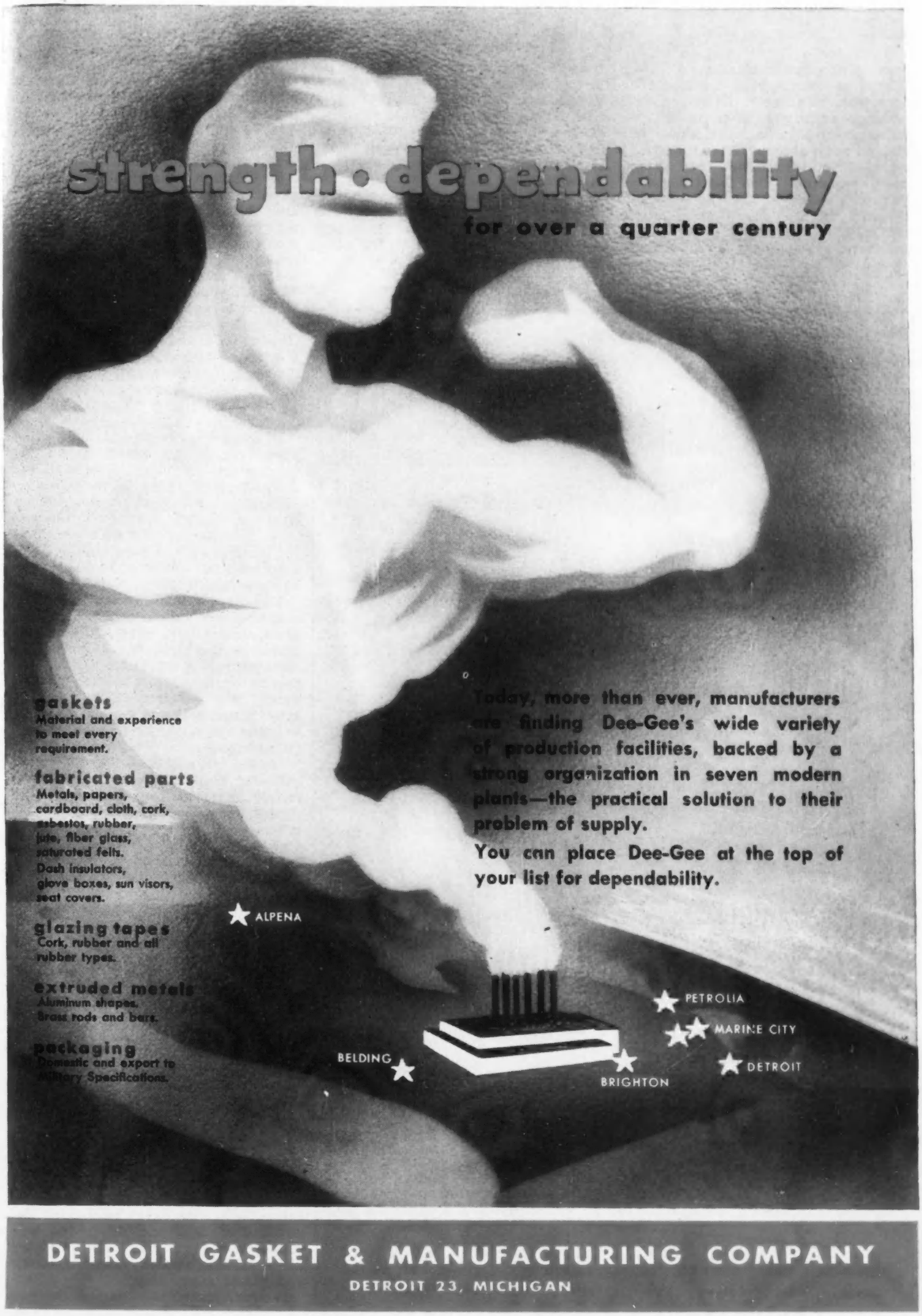
William H. Graves, elected as the 1951-52 Chairman, was introduced at the meeting.

Compares American And European Diesels

• New England Section
C. G. MacDermott, Field Editor

May 1—Nearly 100 members and guests were on hand at this meeting to hear **Robert Cass**, assistant to the president of White Motor Co., and presently on loan to the U. S. Government, speak on diesel engines.

Diesels were first used, Cass said,


strength · dependability
for over a quarter century
gaskets
Material and experience to meet every requirement.
fabricated parts
Metals, papers, cardboard, cloth, cork, asbestos, rubber, jute, fiber glass, saturated felts.
Dash insulators, glove boxes, sun visors, seat covers.
glazing tapes
Cork, rubber and all rubber types.
extruded metals
Aluminum shapes.
Brass rods and bars.
packaging
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PETROLIA
MARINE CITY
DETROIT
BELDING
BRIGHTON
DETROIT GASKET & MANUFACTURING COMPANY
DETROIT 23, MICHIGAN

because no other powerplant available offered the horsepower demanded by operators. At present, however, diesels have no advantage in terms of performance over gasoline engines, but they do use a cycle which is inherently more efficient than that used in the gasoline engine. This is what makes them interesting to the transportation industry today. The slightly lower cost of diesel fuel at the present time, Cass feels, will increase to a level comparable to or above that of gasoline in the very near future.

Cass has recently returned from a trip to Europe where he studied diesel engine developments in that area. Comparing European engines to those of American design, he brought out the following facts:

1. European operators are satisfied with much lower power outputs—120 hp compared with 300 hp here—and lower engine speeds—1800 rpm compared to 2200 to 2700 here. However, they expected and got from their engines substantially better economy, expecting a specific fuel consumption of 0.38 lb per brake-power hour, where we would be satisfied with 0.45 lb per brake-power hour here.

2. Although some highly satisfactory two-stroke diesels are in use both here and abroad, Cass feels that most research will be directed at the four-stroke engines, which offer better efficiency.

3. One two-stroke cycle engine under development in Russia, however, employs a special porting which tends to produce automatic exhausting as a method of increasing power output.

4. Supercharging, although effective, increased fuel consumption out of proportion to the increase in power and resulted in higher loads on engine parts.

In discussing smoke and noise problems encountered where diesels are used in crowded areas, Cass said that a diesel must knock to be operating efficiently, but should not smoke. However, a pilot injection device has been developed which makes a diesel run quietly at idle, and this is being used on some diesel-powered coaches at the present time.

The black smoke produced by overfueling the engine is odorless and not toxic; however, a blue-white smoke, which is the product of incomplete combustion, is offensive. Operators' driving technique and proper maintenance plus tamper-proof injection systems can be made to work together to make the smoke and noise problem unimportant.

Special oils and fuels are not necessary for diesel engines. It has been proved in Europe that the use of high phosphorus cylinder liners reduces cylinder wall wear due to corrosion to an acceptable amount when high-sulfur fuels must be used.

Cass emphasized the importance of designing the engine to use available fuels, rather than building a unit which is useless without a specially designed fuel.

Tells Advantages Of Propane Gas

• Dayton Section

Lewis A. Leonard, Jr., Field Editor

May 15—The use of propane gas as an engine fuel, according to **Robert S. Lee** of the Twin Coach Co., is one of the more recent developments in the automotive field and offers the advantages of lower fuel costs, maintenance savings, greatest handling safety and public acceptance.

Internal-combustion engine design-


A Tisket a Tasket
THERE IS NO BETTER GASKET
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50 YEARS of Gasket Manufacturing Experience
Makes
McCORD
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GASKET Buy
Good sealing is inherent in McCord gaskets. One or a hundred, they are all the same—the best sealing gaskets made. They are Individually Engineered to seal oil, gasoline, or water under any or all conditions of automotive service. Good mechanics specify McCord—the gaskets they know will always make and keep tite joints. There are no better gaskets.
McCORD CORPORATION
DETROIT, 11, MICH.

ers have long recognized the need for a fuel which possesses high-octane rating (propane has 125), resistance to detonation and ideal combustion characteristics. Operators of internal-combustion engines have sought a fuel which would minimize engine maintenance expenditures, give high octane performance, and still be within economic reach.

Lee presented a very convincing story in favor of the use of propane for use in public transportation vehicles, both intra-urban and inter-urban.

Although bulk storage and initial conversion costs may seem high, the statistics presented show that savings in fuel and maintenance costs offset this so that an overall savings results. It can actually cut fuel costs by 2¢ per mile for certain locales and cut engine maintenance costs 50% regardless of location.

The lower Btu content is more than compensated for by its octane rating of 125. Another advantage of propane is its slow burning rate, which gives it smooth power characteristics. With this fuel, there is no detonation at low speed under heavy loads. The fuel gives instant response to the throttle because it enters the manifold as a dry gas. This instant response insures better acceleration.

Propane may be obtained from crude oil at the ratio of 1.05 gal from 42 gal, or from natural gas at the ratio of 1.15 to 1.50 gal per 1000 cu ft.

For successful operation, the minimum compression ratio should be 10 to 1. In the Fageol engine as high as a 14 to 1 compression ratio is used. The fuel is contained in a sealed system under pressure and is fed to the engine through a metering regulator which is fully compensated and remains balanced at all times regardless of changes in barometric pressures and temperatures.

Increase Exhaust Valve Life with Rotating Devices

• Mohawk-Hudson Group

D. C. Peroutky, Field Editor

May 9—Research covering 11,000,000 commercial vehicles miles definitely indicates that normal exhaust valve life can be increased two to five times with rotating devices, said **H. C. Sumner** of Ethyl Corp.

The major factors affecting valve life were said to be the deposit accumulations on valve stems, faces, and seats. A practical method of valve rotation minimizing these deposits has been applied successfully to commercial engines.

There are two principal types of mechanism commercially developed to provide valve rotation. They are known as "free valve" or "Rotovalve" and the "Rotocap."

25 Years Ago

Facts and Opinions from SAE Journal of July, 1926

Car builders are inclined to produce engines of higher compression ratios, because thermal efficiency increases if the compression pressure is raised. The difficulty is that detonation and —in some cases—general roughness are encountered. So, vehicle manufacturers have so far deemed it unwise to increase compression ratios beyond a conservative value until they are assured of universal distribution of suitable fuel . . . Cracked gasolines are gaining in favor because of desirable characteristics from the viewpoint of detonation.—Automotive Research Section

■

Talking of motorcoaches, F. R. Fageol says: "The passenger car has fixed not only the riding habits of the public, but the rate of acceleration and speed up-hill or on the level. Any vehicle that does not approximate these conditions closely must ultimately fail in the transportation field and become a menace to traffic." Fageol is general manager of Fageol Motors of Oakland, Calif.

■

Immediate attention should be given to variations of headlight equipment from designed optical characteristics that result from variations in reflector contour—and to proper location of the light source . . . also to strengthening and other improvement of lamp mountings and the supports to which they may be attached.—Alfred W. Devine, engineer in charge of Equipment Section, Registry of Motor Vehicles, State of Massachussetts in paper, "Common Troubles with Headlighting Equipment."

Of balloon tires for motorcoaches, Firestone's J. E. Hale states: "The motorcoach balloon tire, as compared with the high pressure tire, particularly the 32 × 6-in., is considerably higher. Another inch will mean another inch on the wheel. I should like to urge any tire company that desires to inject new sizes to hesitate —and investigate the cooling and brake problems thoroughly before they begin."

■

A comprehensive outline of aeronautic standardization possibilities has been submitted to the members of the Aeronautic Division of the Standards Committee by Chairman E. P. Warner for determining upon a definite program for the Division's work.

■

Some engineers feel that the tendency of the last few years to build higher speed engines has not been without its adverse affects, according to Herbert Chase, especially in respect to durability. It is certain, in any case, that the possibilities of lower-speed engines with higher torque have not been exhausted.

■

Bevel gears demand constant attention during manufacture, says Arthur L. Stewart of Gleason Works. "Grinding interests us," he goes on, "and we have done some experimental grinding of gears, but we have not progressed far enough to announce definite facts regarding the grinding of spur gears, although we are working along that line."

Students Enter Industry

WILLIAM J. GERSTENMAIER (Yale University '50) to Barden Corp., Danbury, Conn.

OLEN H. KIRCHMEIER (Oklahoma A & M College '50) to Murphy Boiler & Piping Co., Shawnee, Okla.

DANIEL BERRY MARABLE (Parks College) to U. S. Naval Aviation Supply Office, Philadelphia.

JAMES E. RIDGWAY (Indiana Technical College '50) to Ocean City Mfg. Co., Philadelphia.

JOHN H. SPAAN III (Oklahoma A & M College '50) to John Henry's Service Station, Oklahoma City.

BERNARD M. VENESKY (Indiana Technical College '49) to U. S. Navy Bureau of Aeronautics, Washington, D. C.

THOMAS A. THOMPSON (Aeronautical University '50) to North American Aviation, Inc., Columbus, Ohio.

C. R. MONTGOMERY, JR., (University of Colorado '50) to The Texas Co., Wilmington, Calif.

DONALD E. MEAD (John Brown University '51) to Boeing Airplane Co., Wichita, Kans.

LAWRENCE A. VENERE (Aeronautical University '50) to Goodyear Aircraft Corp., Akron, Ohio.

THOMAS LEO PLEIN (Parks College '51) to McDonnell Aircraft Corp., St. Louis.

JOSEPH L. FULBRIGHT (Texas A & M College '51) to Consolidated Vultee Aircraft Co., Fort Worth, Texas.

JACK L. TUTTLE (Tri-State College) to Goodyear Tire & Rubber Co., Akron, Ohio.

FRANK J. CHARHUT (Aeronautical University '50) to Allis Seal Corp., Chicago.

A. GRAVES BOGEL (Texas A & M College '50) to Department of the Army, Red River Arsenal, Texarkana, Texas.

JOHN T. ARIMA (Illinois Institute of Technology '51) to Three Dimension Co., Chicago.

GENE M. CHIAPPARELLI (Rensselaer Polytechnic Institute '51) to The Teleregister Corp., New York City.

MAX R. GRAMLY, JR., (The Pennsylvania State College '51) to Detroit Diesel Engine Division, GMC, Detroit.

MELVIN ALTMARK (Purdue University '51) to Indiana Steel & Wire Co., Muncie, Ind.

ERNEST SCOTT ULM, JR., (University of Illinois '51) to International Harvester Co., Chicago.

JAY ROBERT STOKER (University of Colorado '51) to California State Division of Highways, Sacramento.

TRUMAN PONTO (Cal-Aero Technical Institute) to Century Engineers, Burbank, Calif.

WILLIAM J. POPPE (Northrop Aeronautical Institute '50) to Douglas Aircraft Co., Santa Monica, Calif.

ARL C. REED (Utah State College '51) to Boeing Airplane Co., Seattle, Vash.

DONALD E. BOWEN (Wayne University '51) to Ternstedt Instrument Plant, GMC, Plymouth, Mich.

WILBUR E. DOWNING (University of Massachusetts '51) to Rodney Hunt Machine Co., Orange, Mass.

CLARENCE J. HORNBECK (University of Florida '51) to Aircooled Motors, Inc., Syracuse, N. Y.

FRANCIS HARVEY RAVEN (The Pennsylvania State College '51) to Hamilton Standard Division, United Aircraft Corp., East Hartford, Conn.

DALE E. WOOMERT (The Pennsylvania State College '51) to Sperry Gyroscope Co., Great Neck, N. Y.

ARTHUR A. ROGERS (General Motors Institute) to Rochester Products Division, GMC, Rochester, N. Y.

PAUL "BUD" VERBA (Indiana Technical College '51) to Eastern Engineering Co., Atlantic City, N. J.

NEAL R. DOGGETT (University of Cincinatti '51) to Frigidaire Division, GMC, Dayton, Ohio.

DAN M. ZELINGER (University of Wisconsin '50) to Massey-Harris Co., Racine, Wis.

JULIUS JACOB LORZING, JR., (University of Colorado '50) to Westinghouse Electric Corp., Philadelphia.

JACK G. SWIM (Bradley University '50) to Micro Switch Division, Minneapolis Honeywell Regulator Co., Freeport, Ill.

EDWIN EUGENE ELMGREN (Indiana Technical College '51) to Webster Mfg. Co., Tiffin, Ohio.

GERALD HOWARD DICKINSON (Bradley University '50) to The Oliver Corp., Shelbyville, Ill.

JOHNSON M. TAYLOR (Parks College of Aeronautical Technology '51) to Rice and Holman, Merchantville, N. J.

ELMER R. MOFFITT (Parks College of Aeronautical Technology '51) to McDonnell Aircraft Corp., St. Louis.

ROBERT H. REGIMBAL (University of Montreal '51) to Canadian Aviation Electronics, Ltd., Montreal.

DAVID W. HARRY (Cal-Aero Technical Institute '49) to Piasecki Helicopter Corp., Morton, Pa.

JAMES R. HARNISH (Oklahoma University '51) to York Corp., York, Pa.

JACK E. GREGG (Michigan State College '50) to General Motors Proving Ground, Milford, Mich.

MARVIN LOUIS DAVIS (Oregon State College '50) to Bendix Products Division, Bendix Aviation Corp., South Bend, Ind.

RAYMOND A. PATENAUDE (Rensselaer Polytechnic Institute '51) to General Electric Co., Schenectady, N. Y.

CHARLES J. GREGOROVICH (Indiana Technical College '50) to Economy Pumps, Inc., Division of Hamilton-Thomas Corp., Hamilton, Ohio.

ROBERT J. GREENAWALT (Swarthmore College '50) to Cummins Engine Co., Inc., Columbus, Ind.

ALLISTER WILLIAM SHEPHERD (University of Massachusetts '50) to Boston Gear Works, North Quincy, Mass.

Personals

Continued from Page 86

he held a similar position with that same company in Burbank, Calif.

C. SUMNER McCANN is now a staff engineer in the Research Division of Solar Aircraft Co., San Diego, Calif. Prior to this, he was engaged in test administration in the Special Weapons Division of Northrop Aircraft, Inc., Hawthorne, Calif.

J. C. SHAW has joined the J. R. Meek Co., Tulsa, Okla. Prior to this, he was employed by the Young Radiator Co., Racine, Wis.

WALTER H. SHEALOR is now a field engineer with the Timken Roller Bearing Co., Washington, D. C.

JACK ELLIOTT SCOTT, formerly an engine designer with the Wahl Engine Co., Chicago, now holds a similar position with the Harper Engineering Co., Allentown, Pa. He is engaged in the design of electrical and structural installations in aircraft.

ROBERT G. GREENAWALT is now employed by the Cummins Engine Co., Inc., Columbus, Ind., in the capacity of junior test engineer. He was previously a junior engineer in the diesel experimental department of Fairbanks, Morse, & Co., Beloit, Wis.

KEITH L. PFUNDSTEIN has been appointed manager of agricultural engineering for the technical service division of Ethyl Research Laboratories. He suceeds **DAN M. GUY** who was recently appointed assistant director of the technical service division. Pfundstein has been with Ethyl since 1940, when he joined the corporation as a student engineer.

E. H. SWAYZE is now the owner of Broadway Hardware, Beaverton, Oreg. Prior to this, he was secretary-treasurer of the Lineham Motor Corp., Vancouver, Wash. He was vice-chairman of the SAE Oregon Section in 1933-34 and 1934-35.

R. L. CHARLESWORTH, formerly sales representative for the Boston branch of Mack Motor Truck Co., has been transferred to Manchester, N. H., in the same capacity.

NORMAN L. CARPENTER is presently a checker with Lear, Inc., Grand Rapids, Mich. He previously held a similar position with Packard Motor Car Co., Detroit. He is engaged in checking design and parts for better performance and easier machining.

E. J. CLOUTIER, JR., who, prior to this, was a sales engineer with The Standard Products Co., Detroit, now is employed by Tinnerman Products,

Inc., Cleveland, Ohio, in the capacity of district manager of the Pacific Coast sales office.

J. H. KINDELBERGER, chairman of the board of North American Aviation, Inc., Los Angeles, Calif., recently became a Chevalier de la Legion d'Honneur by decree of the President of France, at ceremonies held at the company's plant. While being presented with the honor, Kindelberger was cited for "the eminent services you rendered the Allied cause during the Second World War and for your outstanding achievements in the field of aeronautical engineering."

WILLIAM H. COATNEY, JR., who, prior to this, was a gage engine supervisor with the Lincoln-Mercury Division of Ford Motor Co., Detroit, is now section supervisor in the engine manufacturing department of that same company. He has complete responsibility for the tooling program necessary to put afterburner assembly, exhaust system, and rear bearing support of an aviation gas turbine into production.

DONALD N. ARNDT has been appointed assistant general sales manager of the Marvel-Schebler Products Division, Borg-Warner Corp., Chicago. Prior to this appointment, Arndt was service sales manager. He is a graduate of General Motors Institute.

DR. TRACY C. JARRETT is now representative for C. I. Hayes, Inc., Providence, R. I. He will serve the area west of the Mississippi, to the Rockies, and south to Dallas. In devoting himself to the heat treating problems of the many firms in this area, Dr. Jarrett will draw upon extremely well rounded experience, comprised of six years as assistant chief metallurgist with the American Optical Co., Southbridge, Mass., followed by nine years as chief metallurgist and later manager of engineering and research with Koppers Co., Piston Ring Division, Baltimore, Md.

J. VEGOSEN now holds the position of assistant project engineer with Wright Aeronautical Corp., Wood-Ridge, N. J. Prior to this, he was senior test engineer with that same company.

R. H. WHEMPNER, director of service engineering of the Aeronautical Division of Minneapolis-Honeywell Regulator Co., Minneapolis, Minn., has been elected assistant secretary of the company. A native of Fargo, N. Dak., and a graduate electrical engineer of the University of North Dakota, Whempner joined Minneapolis-Honeywell in 1935 and spent his first five years with the company in the home office commercial division. With the formation of the aeronautical division in 1941, he was placed in charge of

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the Aero Field Division and supervised a group of more than 150 Honeywell technical representatives serving with the Air Forces at all major bases within the U. S. and in all combat theaters. He was later made sales manager of the aeronautical division prior to his promotion to director of Service Engineering.

LUDWIG L. MOTULSKY, who prior to this, was an automotive project engineer at the Aberdeen Proving Ground, Md., is now a product test engineer with International Harvester Co., Ft. Wayne, Ind., in the Motor Truck Division.

J. TERRY TAYLOR, previously a field engineer with B. F. Goodrich Co., Detroit, is now manager of the track department with that same company in Akron, Ohio.

RICHARD L. MELA is now a senior engineer with Nuclear Development Associates, Inc., White Plains, N. Y. Prior to this he was an analytical engineer with Fairchild Engine and Airplane Corp., Oak Ridge, Tenn. His new position entails the analysis and design of various aspects of nuclear energy.

JOHN S. MARSHALL, JR., is presently a methods engineer with General Electric Co., Somersworth, N. H. He was previously a fire insurance inspector with the National Inspection Co., Chicago.

WILLIAM CARL VOIGT, JR., formerly assistant to the manager of the lubrication and technical service department with Pan Am Southern Corp., New Orleans, La., is presently lubrication and automotive engineer for the state of Tennessee with that same company.

PAUL J. BAUER is now an automotive shop officer with the U. S. Army, Post Ordnance Section, Fort Leonard Wood, Mo. He was previously zone service and mechanical manager with the Chevrolet Motor Division, GMC, St. Louis, Mo. He has supervision of the civilian operated Army shop, and the maintenance of Army vehicles.

WILLIAM D. THOMAS, JR., who, prior to this, was a group leader in the Petroleum Chemicals Laboratory, Stamford, Conn., is presently a technical representative in the petroleum chemicals department of American Cyanamid Co., New York City. He is engaged in the assembling and correlation of technical information for the guidance of development and research programs in the field of lubricating oil additives.

WILLIAM B. SEAVER is presently project engineer with the Allison Division, GMC, Indianapolis, Ind. He was previously associate manager of the technical operations department in the NEPA Division of Fairchild Engine & Airplane Corp., Oak Ridge, Tenn.

MAXWELL N. ANNING is now plant engineer with Barton Instrument Corp., Los Angeles, Calif. Prior to this, he was an instrument technician in the department of engineering at the University of Michigan. He is now in charge of plant layout, production standards, tooling, and plant maintenance.

J. R. MOHLIE, engineering and manufacturing executive and company director of defense operations with The Oliver Corp., Chicago, since 1950, has been appointed works manager of

Continued on Page 112

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Continued from Page 110

heavy line plants with that company. **N. O. PANZEGRAU**, who joined Oliver recently as special projects engineer, was named to succeed Mohlie as director of defense operations. Panzagrau has had major responsibilities as an engineering consultant in foreign operations, and has spent the last 25 years in design engineering and product development work.

LaVERNE MORGAN, formerly Southwestern regional service representative of Cummins Engine Co., has recently taken the position of director of maintenance for the F. N. Rumbley Co., tank truck operators of Fresno, Calif.

THOMAS WOLFE, president of Pacific Airmotive Corp., Burbank, Calif., has been cited by the Executive Office of the President, National Security Resources Board, Washington, D. C., for his outstanding contributions made to the survey through his membership and participation in the Overhaul and Maintenance Task Group. In addition to Wolfe's activities at Pacific Airmotive, he has authored a book on, "Air Transportation, Traffic and Management."

HANS A. HUG, formerly employed at Brown University as an instructor and research assistant, is presently with the Aircraft Gas Turbine Division of General Electric Co., Boston, Mass.

JOHN R. QUINZIO, P. E., formerly chief engineer of the Campbell Elevator Co., Buffalo, N. Y., is now plant engineer of the American District Steam Co., N. Tonawanda, N. Y.

S. HAROLD BEACH, previously assistant chief engineer with Donaldson Co., Inc., St. Paul, Minn., has been promoted to chief engineer. The company produces automotive air cleaners and mufflers.

HARVEY S. FIRESTONE, JR., chairman of The Firestone Tire & Rubber Co., recently arrived from Europe where he attended the International Rubber Conference in Rome for the U. S. Department of State and held a series of conferences with Firestone European distributors, dealers and executives of Firestone European plants. Speaking of the rubber situation, Firestone said, "The crisis in rubber is over. Our rubber problems have been surmounted chiefly through greatly increased production and the acquisition of a substantial stockpile."

RICHARD E. WILKINSON is now with the U. S. Air Force at Chanute Air Force Base, Ill. He holds the rank of staff sergeant, and is engaged in engine build-up. Prior to this, he was employed by the Goodyear Aircraft Corp., Akron, Ohio, in the capacity of junior aircraft weight engineer.

CLAIR M. ROBERTSON, who, prior to this, was a sales representative for the Reynolds Metals Co., Milwaukee, Wis., is presently regional sales representative in charge of industrial and packaging sales in the Omaha territory, for that same company.

R. L. STALLARD is now employed at the Applied Physics Laboratory of The Johns Hopkins University in the capacity of associate engineer. He was formerly research engineer with North American Aviation, Inc., Downey, Calif.

GEORGE E. ZORINI now holds the position of sales engineer with the Reeves Pulley Co., Columbus, Ind., at the Chicago branch of the company. Prior to this, he was lubrication en-

Continued on Page 114

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Loaders . . . and many others

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Continued from Page 112

gineer with the Phillips Petroleum Co., Indianapolis, Ind.

JOSEPH E. MUCCIOLI is presently staff quality control technical assistant with Ford Motor Co., Dearborn, Mich. He was previously a project engineer with the Kaiser-Frazer Corp., Willow Run, Mich.

ILIA I. ISLAMOFF has been promoted from the position of supervisor of sheet metal department to that of assistant production manager of the Pusey and Jones Corp., Wilmington, Del.

HAROLD N. MYERS is presently sales and development manager of the Centrifugal Foundry Co., Muskegon, Mich. He was previously chief metallurgist with the Perfect Circle Corp., Hagerstown, Ind.

WALTER A. KNITTLE now holds the position of mechanical research engineer in the research department of United Aircraft Corp., East Hartford, Conn. Prior to this, he was employed by the Hartford Electric Light Co. as a cadet engineer.

DOUGLAS H. MOORE, formerly test engineer with the Hudson Motor Car Co., Detroit, is presently a mechanical engineer with Harry Ferguson, Inc., Detroit. The company is engaged in the manufacture of farm equipment.

DONALD K. PLANK, who, prior to this, was employed in the National Fleet Division of Studebaker Corp., South Bend, Ind., is now with the Hudson Sales Co., Dallas, Texas. He is a developing and managing dealer in west Texas.

S. E. ELLENBE now holds the position of fleet engineer with the Ethyl Corp., New York City. Prior to this, he was employed by Safety Tire Gauge, Inc., Atlanta, Ga., as chief engineer. He is consultant to oil company engineers on fuel and maintenance problems.

W. H. deBRUIN, formerly a development engineer with The Goodyear Tire & Rubber Co., Akron, Ohio, is now a resident engineer with that same company in Detroit.

JOHN D. BAILIE has been promoted from research engineer in the Ethyl Corp.'s Detroit laboratories to chief automotive engineer in the Central sales region of that same company. Bailie joined Ethyl Corp. in 1939 as an assistant research engineer in the Detroit laboratories. He served briefly with the U. S. Army in 1941 and for three years between 1942 and 1945 he was an ordnance engineer with the Naval Ordnance Laboratory. He returned to Ethyl's research laboratories as a technical report writer, and for the past four years he has been a research engineer with the Technical Service Division, first with the commercial engine and fleet section, and more recently with the agricultural section.

JOE M. LYON, JR., formerly an engineer with Cook Brothers Equipment Co., Los Angeles, is presently a design engineer with the Anderson Barngrover Division of Food Machinery & Chemical Corp., San Jose, Calif.

ALBERT L. LONGARINI, formerly an aircraft and engine mechanic with the Phillipsburg Airport, Phillipsburg, N. J., is now employed by the Glenn L. Martin Co., Baltimore, Md., as assembly inspector, second-class.

H. E. GLASNOFF is now a lubricating engineer with the American Oil Co., Washington, D. C.


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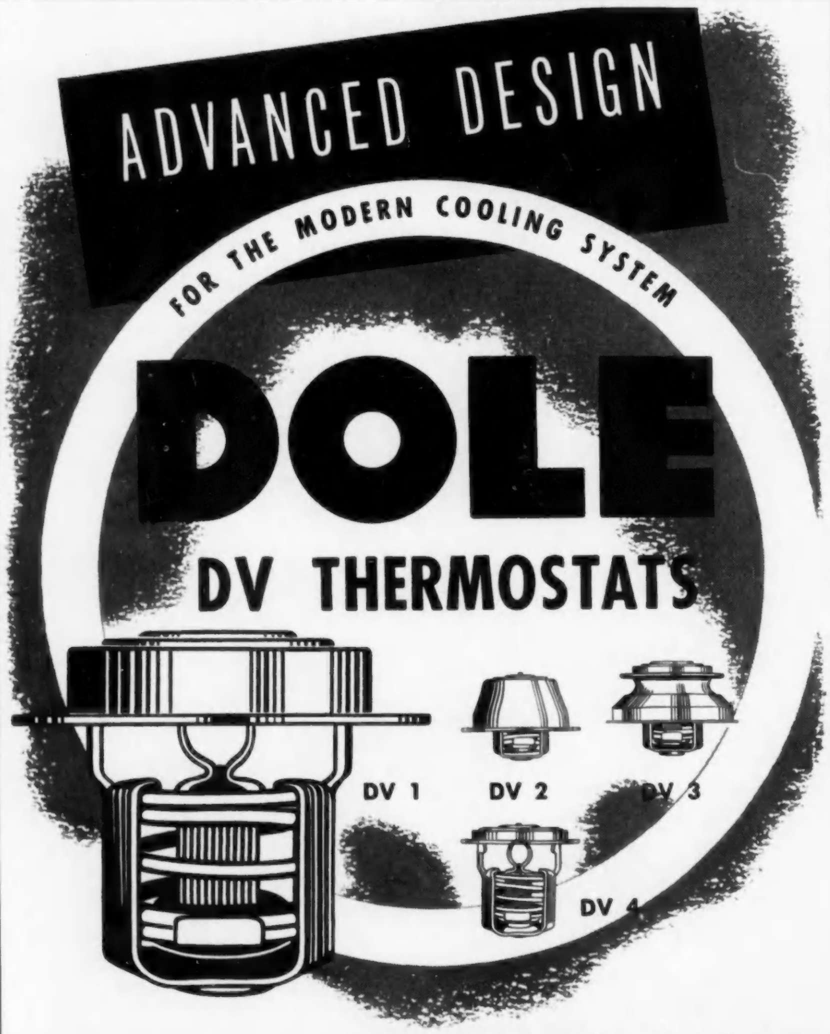
Continued from Page 77

much stretch of the imagination to pick a new figure of five mph overall average speed. Remember, the operator has a 1500 hour performance figure in mind and we now have an increase of 25% in tire mileage at the same "hour" yardstick. It is difficult to get any contractor to admit to such improved machine output, but I am convinced it is real and must be given consideration in evaluating tire service. It is another reason for studying new designs and specifying the proper size and type of tire as original equipment. (Paper "Engineering the Tire to the Vehicle" was presented at SAE Central Illinois Section, Earthmoving Industry Conference, Peoria, Ill., April 10, 1951. It is available in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)



Small Design Details Can Add to Safety

Based on paper by

HOWARD K. GANDELOT

General Motors Corp.

PUBLIC acceptance and possible benefit to the majority of motorists is the necessary basis for evaluation of safety advantages to be contributed by a new device or change in design. And the motorists' convenience is another important consideration. It is better for the industry if the merit of a safety feature be judged from factual determinations instead of by its possible value to the advertising agency copywriter.

From the standpoint of real safety, minor details of design can be important ones in reducing ordinary hazards which might cause scratches or cuts. Such details would be sharp corners on doors and deck lids, sharp sheared bottom edges of instrument panels and front seat frames, the lifting edges of hoods, corners of drip moulds and decorative moulding, saw teeth edges that plating sometimes builds up on bumper edges, fuel tank filler openings, and doors on rear fenders. (Paper "Engineering Safety into Automobile Bodies," was presented at SAE National Passenger Car, Body and Materials Meeting, Detroit, March 7, 1951. It is available in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)

What Additives Can Do For Diesel Fuel

Based on paper by

W. E. ROBBINS

R. R. AUDETTE

and

N. E. REYNOLDS, III

U. S. Navy

TESTS carried out at the U. S. Naval Engineering Experiment Station revealed a large number of compounds of various types to be effective in raising the cetane number of diesel fuels. Increases of 20 or more units came from using certain peroxides, alkyl nitrates, nitro alkanes, and nitro carbamates in concentrations of 1.5%.

It was also found that many additives lost their effectiveness when blended in diesel fuel and subjected to certain storage conditions. Blends of 39 cetane number catalytically cracked fuel with either the nitro carbamate or

peroxide type additives were stable during 24 weeks of storage. The nitro alkane blend lost most of its effectiveness within 18 weeks and the nitrate blend within six weeks.

Generally speaking, fuels with additives have a higher carbon residue on 10% residuum than undoped fuels. This value for all the diesel fuel base stocks tested was increased up to 10 times the original value by the addition of 2% or less of alkyl nitrate, nitro alkane, or nitro carbamate additives.

In some instances the additive was responsible for raising the neutralization number and/or flash point. However, this effect is regarded as unimportant unless the flash point is lowered to unsafe values.

Other findings, based on laboratory engine tests, were that certain additives caused piston ring sticking, but did not increase deposits materially on engine parts outside the piston ring belt. In general these additives reduced exhaust smoke slightly and under certain conditions facilitated starting. Power output was reduced a little, but the opposite was true under certain conditions of supercharging. Fuel consumption was increased slightly or not at all, while maximum cylinder pressure, rate of pressure rise, and ignition lag was generally decreased.

These additives gave no indication of increasing piston ring wear, but in one instance may have contributed to exhaust and injector valve sticking, and to diaphragm corrosion in a cylinder pressure pick-up.

Further studies are recommended because of the value to the Navy of a completely suitable additive, and availability of high ignition quality diesel fuel irrespective of pour-point limitations. Furthermore, naval engines may sometimes require fuel with cetane numbers above 50. (Paper "Performance and Stability of Some Diesel Fuel Ignition Quality Improvers," was preented at SAE National Fuels and Lubricants Meeting, Tulsa, Nov. 9, 1950. It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

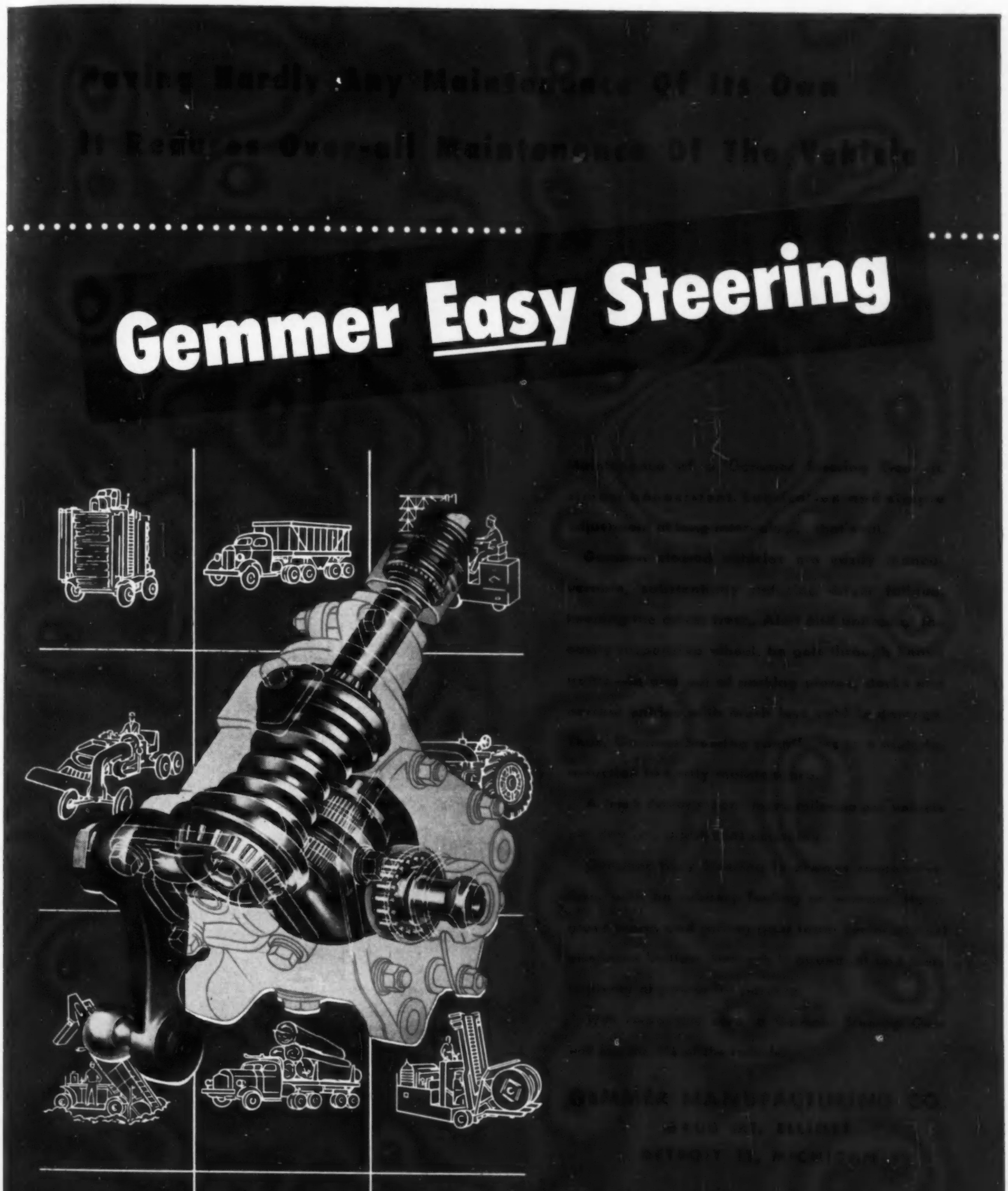
We've Forgotten Some Fuel Problem Aspects

Based on paper by

T. B. RENDEL

Shell Oil Co.

A TREMENDOUS amount of time and effort is still being spent in investigating ways and means for measuring and overcoming the phenomenon of fuel combustion known as detonation. The problem is still important in fitting a fuel to an engine, but it isn't the only problem. There are three other aspects which should be considered. These are: ability to maintain consis-


Gemmer Easy Steering
Gemmer Has Been Making
Steering Gears for Motor Vehicles
for 43 Years

tent performance, durability, and driving technique.

Many of the ills affecting internal combustion engines can be traced in some form or other to the necessity of getting rid of large quantities of waste heat and to the fact that combustion is rarely complete and that certain parts of it are left behind in the form of deposits or acids.

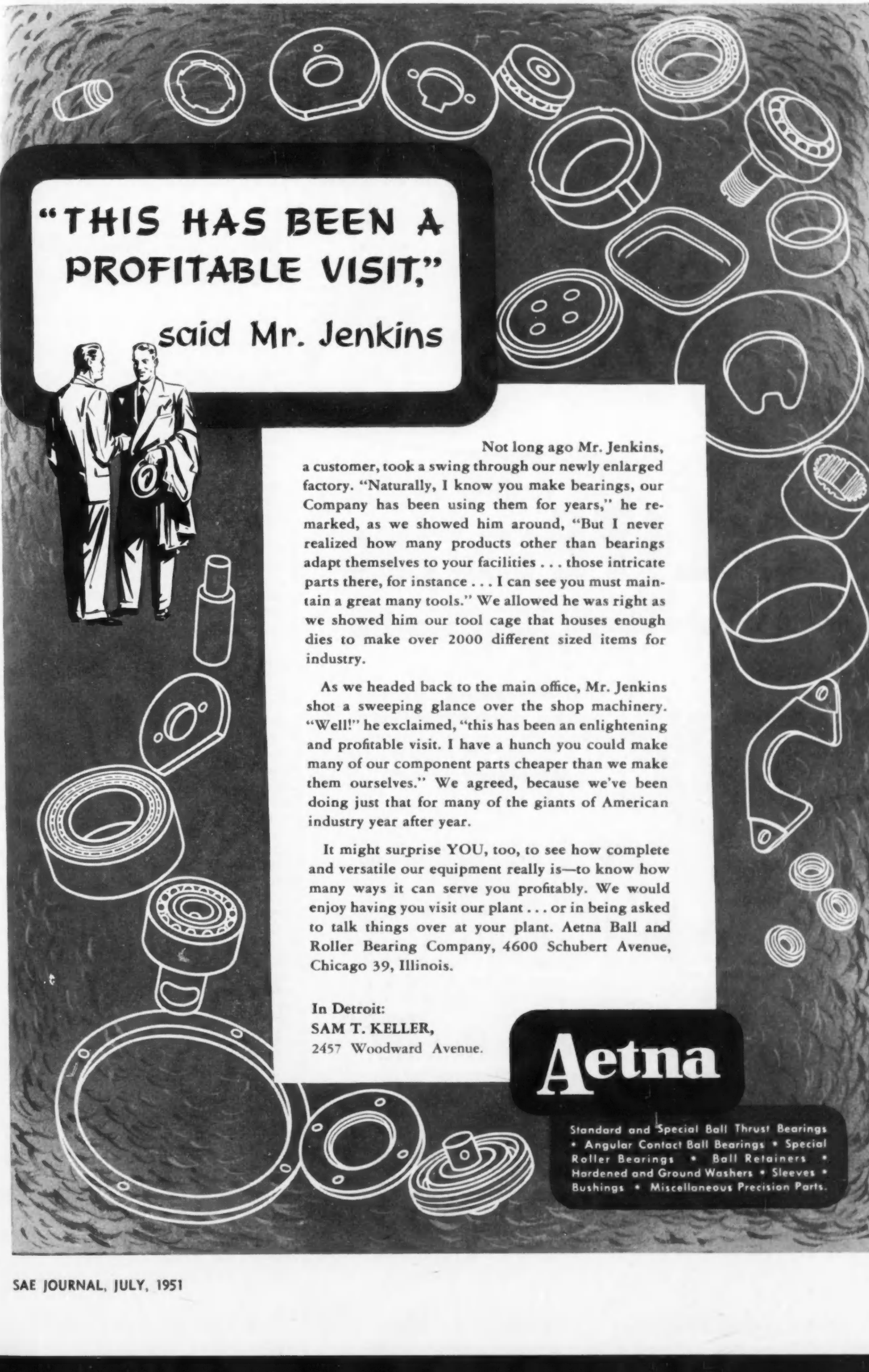
Again, since cars are operated at part throttle for the greater portion of the time, high compression ratios and advanced spark timings are necessary to obtain good economy. This means in turn that suitable devices must be employed for insuring proper spark timing at all speeds and throttle openings. Such devices get out of adjustment quite easily and have a marked effect on the tendency of a car to knock on any given fuel. These two features — combustion chamber deposits and maladjusted spark timings —introduce an oft forgotten aspect into the engine-fuel relationship with regard to knock tendency, that is, the awful inconsistency in the performance of cars of supposedly similar performance.

Inconsistency presents a challenge to both automotive and petroleum industries. Any improvement either industry can achieve is sure to result in a greater percentage of cars being satisfied with the fuels currently available. The engine industry should tackle the problem of variable spark timings and their effect on engine performance, while the petroleum industry could study the question of combustion chamber deposits.

An engine must be durable, that is, must be economical in repairs required. Excessive deposits can cause premature overhaul, but we are concerned here with the problem of metal wear which means new parts.

When we think of using lube oil additives for combatting wear, an obvious source to investigate is the large group developed to alleviate sticking rings, dirty cylinders, and heavy lacquer formation. A few of these additives have significant antiwear properties, particularly in regard to neutralizing the effect of the acids formed by partial combustion of sulfur-containing fuels. It is well established that under certain conditions wear is caused by corrosive action of partially burned gases condensing on the film of oil on the cylinder wall. Hence, the right amount and proper selection of additives is important.

Admittedly, fuel economy is hardly one of the forgotten aspects of the engine-fuel relationship. Nevertheless, many factors governing economy are sometimes overlooked and driving technique is one of them. Driving conditions and the way a car is driven are a major factor in obtaining economy. In any investigation of a complaint of a fuel's behavior, the driver of the vehicle and driving conditions deserve as close attention as the vehicle and the fuel, if not more so. It is the most difficult side of the problem to


"THIS HAS BEEN A PROFITABLE VISIT,"
said Mr. Jenkins
Not long ago Mr. Jenkins, a customer, took a swing through our newly enlarged factory. "Naturally, I know you make bearings, our Company has been using them for years," he remarked, as we showed him around, "But I never realized how many products other than bearings adapt themselves to your facilities . . . those intricate parts there, for instance . . . I can see you must maintain a great many tools." We allowed he was right as we showed him our tool cage that houses enough dies to make over 2000 different sized items for industry.
As we headed back to the main office, Mr. Jenkins shot a sweeping glance over the shop machinery. "Well!" he exclaimed, "this has been an enlightening and profitable visit. I have a hunch you could make many of our component parts cheaper than we make them ourselves." We agreed, because we've been doing just that for many of the giants of American industry year after year.
It might surprise YOU, too, to see how complete and versatile our equipment really is—to know how many ways it can serve you profitably. We would enjoy having you visit our plant . . . or in being asked to talk things over at your plant. Aetna Ball and Roller Bearing Company, 4600 Schubert Avenue, Chicago 39, Illinois.
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Aetna
Standard and Special Ball Thrust Bearings • Angular Contact Ball Bearings • Special Roller Bearings • Ball Retainers • Hardened and Ground Washers • Sleeves • Bushings • Miscellaneous Precision Parts.

study and on which to get reliable data.

(Paper "Some Frequently Forgotten Aspects of Today's Engine Fuel Problem," was presented at SAE Buffalo Section, Jan. 18, 1951. It is available in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

How to Get Performance From Tires in Sand

Based on paper by
ROBERT V. SNYDER
B. F. Goodrich Co.

REGARDLESS of terrain, the best mobility of any vehicle is obtained by selecting tire equipment to provide the optimum combination of low rolling resistance and high available tractive effort or ability.

Except for reducing gross vehicle weight, whatever is done for the tire equipment in sand to reduce rolling resistance will increase drawbar pull or useful tractive effort. This is not necessarily true on snow, mud, or on a hard surface. Whatever is done to towed equipment to decrease the effort required to tow it, will also improve the performance of the vehicle as if it were self-propelled.

To reduce rolling resistance and improve flotation in sand:

1. Use large single tires instead of duals.
2. Have all wheels track on each side of the vehicle.
3. Design tires for—(a) round profile, (b) flexible carcass (for example minimum plies), (c) shallow tread and undertread, (d) uniform crown and shoulder gage.
4. Lower tire inflation.
5. Reduce tire load. Tires should not be loaded to more than 50 to 85% maximum rated load depending on size and sand condition.
6. Equalize load distribution on all tires.

To increase useful tractive effort:

1. Employ the same steps outlined above except 5. Increased tire load results in higher available tractive effort, but not in a linear relationship. The rate of gain in traction is diminished at successively higher load increments.
2. Make all wheels driving wheels.
3. Use enough horsepower to permit use of total available traction provided by tires at speeds above 3 mph.

(Paper "The Performance of Earthmoving Tires in Sand," was presented at SAE Earthmoving Industry Conference, Central Illinois Section, Peoria, April 11, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members; 50¢ to nonmembers.)

New Members Qualified

These applicants qualified for admission to the Society between May 10, 1951 and June 10, 1951. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member; (FM) Foreign Member.

British Columbia Section

Louis Frank Bonar (J).

Buffalo Section

Dr. William H. Millett (M), Reidar A. Tollefsen (M).

Canadian Section

J. Robert Beale (M), Roy Robertson Borland (J), Frank Dowell Crowder (M), Wilbur C. Holt (A), Richard H. Howell (A), Robert Trant Jarman (J).

Central Illinois Section

LeRoy S. Linn (M), Karl L. Mason (M).

Chicago Section

Charles R. Flint (M), Clarence Gaughen (M), Ralph Clinton Goetz (J), Arthur R. Hempe, Jr. (A), Joseph C. Margetic (M), John J. Sichman, Jr. (M), Burton K. Snyder (J), Donald E. Wing (J).

Cincinnati Section

Paul G. Blazer, Jr. (A).

Cleveland Section

Elmer Milton Anderson (A), Jack A. Hart (M), Clarence A. Jarosz (A), Laddie J. Pesek (M), Wilbur J. Scheutzow (M).

Colorado Group

Edward V. Garnett (M).

Dayton Section

Chauncey K. Haynes (M), Homer B. Nelson (M).

Detroit Section

James W. Ames (A), Roy E. Batie (M), Don A. Cargill (M), Samuel Kelly Clark (J), John L. Daddow (J), Merrill W. Dixon (A), Louis E. Farkas (M), George J. Gaudaen (A), John R. Hull (M), Roy Hummel (M), William Mabrey Hutchison (J), Milanko Ikach (J), J. Emmet Judge (A), John R. Lees (J), Dale B. McCormick (M), Floyd C. Melby (M), Allen K. Parrish (A), Richard A. Ramsay (M), Richard E. Rassel (A), Lee William Rehbein (J), Howard B. Schweppe (A), Robert W. Smith (M), David V. Tinder (J).

Hawaii Section

David F. Wisdom (A).

Continued on Page 124

New Members Qualified

Continued

Indiana Section

W. Loing McCarthy (M).

Kansas City Section

Hal L. Dickerson (A), William N. Hinds (SM).

Metropolitan Section

Paul M. Bishop (M), Gaston Fleischel (M), Thomas J. Harris (M), Franklin W. Kolk (M), Paul J. Lederer (M), R. H. McGough (M), Edward H. Raiguel (M), Henry S. Wilson (A).

Mid-Michigan Section

Earl L. Schaper (M).

Milwaukee Section

James L. Gillis (M), G. Reuter (M), Whitney Snyder (M), Fred R. Zwanzig (A).

Montreal Section

Robert Frederick Bartlett (J), Alan Stride (A).

New England Section

Edwin Braverman (A), Richard Y. Grant (A), Frank H. Grinnell (A), Walter J. Holt (A), William J. McCurdy (M).

Northern California Section

Dave C. Stilleke (A).

Northwest Section

Averil Dean Walker (J).

Philadelphia Section

Robert George Kurtz (J).

San Diego Section

John A. Benton (M).

Southern California Section

Carlton Reed Chatten (A), Robert W. Houston (M).

Syracuse Section

James D. Cregan (M), Edwin Roy Smith, Jr. (J).

Texas Section

Ollie James Smith (A).

Washington Section

Paul Louis Genevey (FM).

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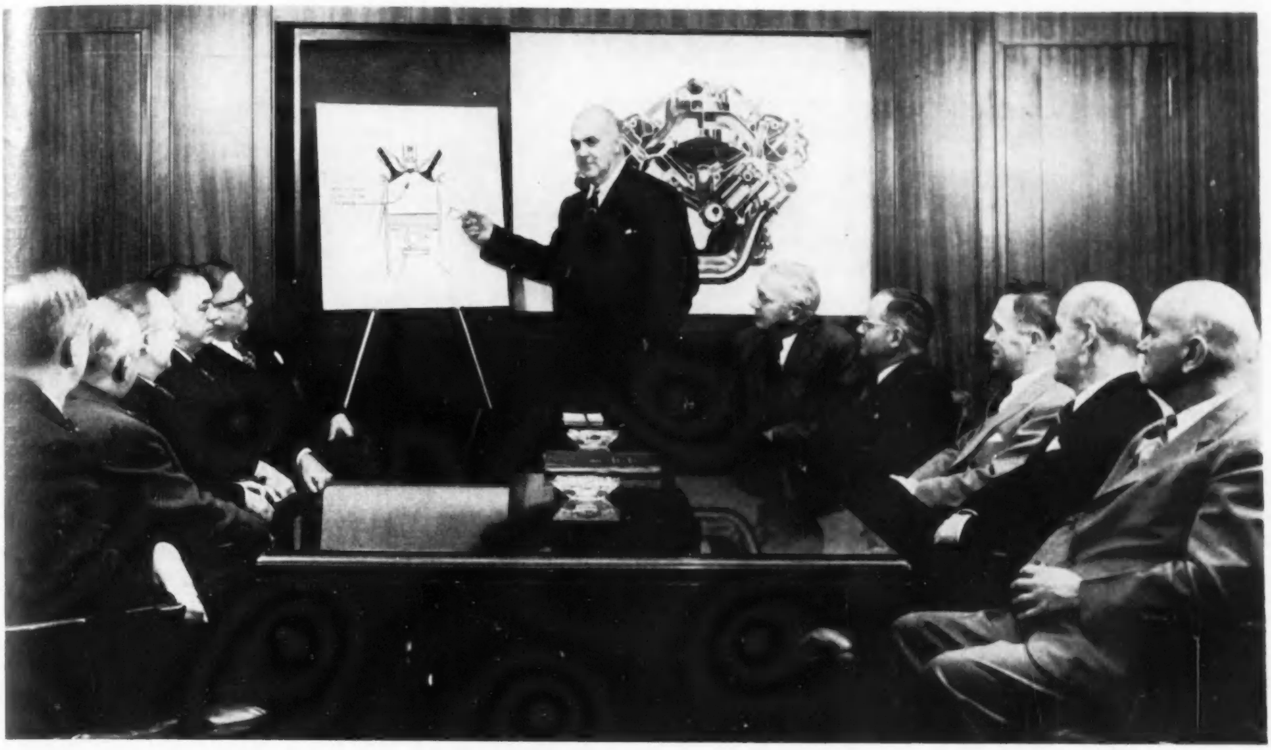

Among Chrysler's Top Engineers . . . .

. . . . SAE Journal Readers Predominate

When Chrysler's Director of Engineering and Research James C. Zeder calls his top engineers into conference, eight out of eleven of them are readers of the SAE Journal . . . Among them are rising young men and well-known veterans. SAE Journal has been coming to one of them for over 35 years; to one of them for only 5 years. (The average is 24 years).

. . . The Chrysler story is typical. In other automobile and truck companies, in plants which make airplanes, aircraft powerplants, diesel engines, road machinery, parts and accessories . . . everywhere that top-flight automotive engineers gather to make technical decisions, SAE Journal readers are likely to be a majority of those present.

SAE JOURNAL

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New Members Qualified

Continued

Williamsport Group

Ewing Wilson Mueseler (M).

Outside of Section Territory

Joseph A. Bennett (M), Adolph Berg (A), J. P. Brownlow (A), Capt. Arthur R. Chase (SM), J. Lowry Dobbs (A), Wendell Howard Gray (J), Gordon Charles Mann (A), John Alex Steeves (A), M. H. Willcher (SM).

Foreign

Jose Jorge Canelas (J), Portugal; Riccardo Casiraghi (FM), Italy; William John Collins (J), Peru; Norberto Garcia, Jr. (M), Puerto Rico; O. Z. Johnson (A), South America; Noel Ager Mackay (FM), New Zealand; Frank Noel McGowen (FM), Australia.

Applications Received

The applications for membership received between May 10, 1951 and June 10, 1951 are listed below.

Baltimore Section

Ray F. Wilkie.

British Columbia Section

Alex. A. Frew.

Buffalo Section

Robert John Armstrong, Edgar J. Reichelderfer.

Canadian Section

Winston Robert Boyle, Robert S. Bridge, Jock Ackland Gillies, A. C. Jackson, William E. Ireland, George W. Read, Herbert E. Robinson, Rhys M. Sale.

Chicago Section

Walter O. Bullock, Victor R. Farlow, Harry Halinton, Edward H. Johnson, Richard W. Kramer, James E. Murphy, Robert John Neubacher, Carl Victor Pearson, Howard J. Peterson, Ralph V. Rentzsch.

Cincinnati Section

John Joseph Eldridge, II, Charles L. Hebel, Jack D. Kelly, Herbert C. Lazarus, Jr., David N. Miller, Edward J. Schmerber, Robert H. Stang.

Applications Received

Continued

Cleveland Section

John L. Davies, John E. Fahlman, George B. Longan, Lathum G. Luikart, Robert Charles Miller, John A. Mosley, Stephen Nagy, John Rogos, Jr., Karl W. Strasser, Werner F. Timm, George Utz, Rudolph A. Walters, Jr.

Dayton Section

Frederick J. Clemens.

Detroit Section

Stanley E. Albertson, Jr., Harold K. Barte, Arthur S. Bassette, Stanley E. Blake, Edgar Clarke Campbell, Ernest Charlebois, John Gardner Coffin, Jr., Gerald W. Dalder, John Dykstra, William Stanley Edwards, E. B. Evans, Markham J. Finn, Raymond Grose, Donald H. Hartmann, John G. Haviland, George C. Hedges, Edward D. Heins, Robert J. Hefferon, Curtis J. Hendricks, Harold S. Howe, Richard F. Jacobs, William H. Jennings, John F. Kelly, Raymond N. Kreucher, Francis C. Lorimer, Jr., Sulo Maki, Archibald O. Mason, William Donald McClellan, William H. McDonald, William L. Miron, Richard W. Nicholas, Gillette Weldon Parker, Leo S. Parry, W. C. Patterson, Kenneth A. Pickering, R. M. Purdy, Philip Floyd Rabbidge, John T. Rauen, Albert Resnick, Paul J. Rhoads, Norman L. Rissanen, George A. Rock, Philip M. Rogers, David William Roth, M. E. St. Aubin, Thomas J. Schultz, M. Virginia Sink, Marshall Sittig, Walter F. Skinner, John R. Smith, Jeremy J. Stevens, Donald B. Tipping, Roderick Graham Tipping, Stephen J. Tompkins, John D. Tuckfield, Carson M. Wallace, George H. Webb, Jervis C. Webb, Earl Stanley Welch, John E. Willett, Quinby Edmund Wonn.

Hawaii Section

Yutaka Hirata, Edward R. Kuwaye, Antone Milho, Thomas H. Wilkerson.

Indiana Section

William J. Richards, William C. Sweeney.

Metropolitan Section

John K. Appeldoorn, Harlen H. Byers, Solomon S. Dorfman, Hector Charles Evans, Sidney W. Fay, Richard S. Ferris, Gerard Francis Geigle, Richard M. Howlett, John J. Kolfenbach, Edwin D. Maxfield, Edmund J. Rotchford, Sr., John H. Smithson.

Mid-Continent Section

Don A. Duling, Rush Simonson.

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Applications Received

Continued

Mid-Michigan Section

David Hadden, Chilton K. Jensen, Stanford Landell, F. Richard Merriam, Robert S. Tooker.

Milwaukee Section

Weichien Chow, Clarence A. Rasmussen.

Montreal Section

Frank Lyon.

New England Section

Horace T. Brooks.

Northern California Section

Paul Gustav Noack, Frank Fred Petersen, P. L. Pinotti.

Northwest Section

William Henry Davison, Ray Clifton Herd.

Oregon Section

James F. Bessire.

Philadelphia Section

James C. Burke, Neal Devere Lawson, John D. Young.

Pittsburgh Section

Kenneth R. Schaper.

St. Louis Section

Raymond L. Moy, Noel S. Reynolds.

Salt Lake Group

William J. Luttrell.

San Diego Section

Paul L. Brady.

Southern New England Section

Albert I. Alstrom.

Syracuse Section

George S. Sherman.

Texas Section

Garold D. Walters.

Twin City Section

Robert A. Hill, Farris Hardin Woods.

Western Michigan Section

Nathan H. Rewalt.

Wichita Section

Cordy Wiley Jones.

Outside of Section Territory

Francis Henry Morgan, Donald L. Reichelt.

Foreign

Frederick W. Clarke, England; Richard Philip Wildey Morris, England; Mufti Mohammed Salim, Pakistan; Frederick William Winyard, Hong Kong.

For the Sake of Argument

Your Audience is a Parade . . .*

By Norman G. Shidle

The tunesmith that wrote "I Love a Parade" must never have had an organization to train . . . nor ideas to fix in people's minds. He wasn't worrying about selling products or policies, nor about exchanging technical data.

All he had in mind was standing there cheering while the columns marched and the bands played. He wasn't worrying about teaching the marchers to do better everyday jobs; about explaining democracy to them as they marched—or even about selling them badges.

It must have been that way. That's the only basis on which anybody can love a parade.

Ask any executive who has to build an effective working force with 10 or 20% of it coming in new each year—and an equal part going over the hill and out. . . . Ask any editor who serves technical articles to the ever-moving parade of a professional society membership. . . . Ask any sales manager who has to shout his wares and complete his sales to the buyers who parade past from youth to old age.

These people don't love a parade. They would much rather have an audience stay put. Just about the time somebody has understood their ideas or bought their products, he has passed the reviewing stand. Somebody new has come along in his place.

Suppose you're trying to sell elephants (or ideas or facts and policies.) There are at least 3,000,000 people in America today who have never *seen* an elephant. And next year there will be 3,000,000 more . . . and 3,000,000 more the year after that. There are always new people to teach, to sell, to get to understand.

Any purveyor of ideas is talking to a parade, not a static audience. Concepts must be judged new or old, understood or unknown by the people who receive them. Data new to the oncoming marchers may be old to those who have already passed the loud-speaker. Any single thing is old stuff to some, new stuff to others.

Too many ideas are packaged and broadcast for the needs of fixed audiences; not enough are tuned to the ears of the passing paraders. Yet the paraders are the only audience which really exists.

* The spark for this editorial was struck by Kenneth McFarland's talk to the Second Annual Earthmoving Conference staged by SAE's Central Illinois Section at Peoria, in April, 1951. To McFarland we owe in particular the "3,000,000 people who have never seen an elephant"—and the "parade" idea in general.